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B A N I S T E R I A

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Cover: The Virginia Natural History Society's logo is based around sketches of a fern (*Woodwardia virginica*) and shark's tooth (*Carcharodon* ?) drawn by John Banister (1650-1692), Virginia's first university-trained naturalist.

Back cover: *Arisaema triphyllum* (Linnaeus) Schott (Jack-in-the-pulpit). Original drawing by John Banister. Figure 45 in folio in Hans Sloane's MS 4002 in the British Museum of Natural History. Photograph courtesy of Joseph and Nesta Ewan.

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Land Snails and Slugs (Gastropoda: Caenogastropoda and Pulmonata) of Two National Parks along the Potomac River near Washington, District of Columbia

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ABSTRACT

The land snails and slugs (Gastropoda: Caenogastropoda and Pulmonata) of two national parks along the Potomac River in Washington DC, Maryland, and Virginia were surveyed in 2010 and 2011. A total of 64 species was documented accounting for 60 new county or District records. *Paralaoma servilis* (Shuttleworth) and *Zonitoides nitidus* (Müller) are recorded for the first time from Virginia and *Euconulus polygyratus* (Pilsbry) is confirmed from the state. Previously unreported growth forms of *Punctum smithi* Morrison and *Stenotrema barbatum* (Clapp) are described.

Key words: District of Columbia, *Euconulus polygyratus*, Gastropoda, land snails, Maryland, national park, *Paralaoma servilis*, *Punctum smithi*, *Stenotrema barbatum*, Virginia, *Zonitoides nitidus*.

INTRODUCTION

Land snails and slugs (Gastropoda: Caenogastropoda and Pulmonata) represent a large portion of the terrestrial invertebrate fauna with estimates ranging between 30,000 and 35,000 species worldwide (Solem, 1984), including at least 523 native taxa in the eastern United States (Hubricht, 1985). Known extinctions of land snails are disproportionately high and there is clear evidence that over the last few hundred years snail extinctions have exceeded those known for all other animal groups combined (Lydeard et al., 2004; Naggs, 2006). Land snails are thought to have low vagility, often migrating only a few meters per year (Arnaud et al., 1999), but recent studies suggest that dispersal may be facilitated by rafting in some species that occur near rivers (Sinclair, 2010), or in the case of the Japanese snail *Tornatellides boeningi* (Schmacker & Boettger), by traveling while in the digestive tract of birds (Wada et al., 2011).

Although county-level distributions of native land gastropods have been published for the eastern United States (Hubricht, 1985), and for the District of Columbia and Maryland (Grimm, 1971a), and Virginia (Beetle, 1973), no published records exist specific to the areas inventoried during this study, which covered select national park sites along the Potomac River in Washington D.C., central Maryland, and northern Virginia. In an effort to protect better the land snail fauna of these park areas, this study sought to provide habitat, relative abundance, and site-specific location data to identify important areas for land snail conservation at these national park sites.

STUDY SITE

Inventories were conducted on lands managed by the National Park Service, National Capital Parks-East (NCPE) and the George Washington Memorial Parkway (GWMP). The survey area is encompassed by

these coordinates (WGS84 Geographic Coordinate System): N 39.007 W -77.255, N 38.667 W -77.075, N 39.006 W -77.265, and N 38.806 W -76.999. While all sites deemed to have potential snail habitat within the GWMP were surveyed, including sites in the District of Columbia (Theodore Roosevelt Island [RI]), and Virginia (Arlington Co.: Potomac Heritage Trail [PH], Roaches Run Waterfowl Sanctuary [RR]; Fairfax Co.: Great Falls Park [GF], Turkey Run Park [TR], Dyke Marsh [DM], Fort Hunt [FH], Little Hunting Creek [LH]; City of Alexandria: Daingerfield Island [DI], Jones Point Park [JP]), only portions of NCPE along the Potomac River were surveyed, including sites in the District of Columbia (Oxon Cove [OC]) and Maryland (Charles Co.: Piscataway Park [PP]; Prince Georges Co.: Fort Foote [FF], Fort Washington [FW], OC, and PP). These sites lie in the Piedmont and Coastal Plain physiographic provinces and contain a diverse array of habitats including wetlands, meadows, and calcareous and acidic, deciduous dominated woodlands. The vascular flora of these areas is correspondingly diverse with 988 taxa documented from Piscataway and Fort Washington Parks (Steury & Davis, 2003) and 1,313 taxa from the GWMP (Steury et al., 2008; Steury, 2011). The historic forts and Endicott batteries created between 1824 and 1903 at Fort Washington and Fort Hunt are located in open areas, surrounded by mowed turf grass or irregularly maintained meadows, except for Battery Emory in Fort Washington Park, which is now surrounded by second growth woodland at the crest of mature, deciduous, shell marl ravine forest. Other important sites included the narrowleaf cattail (*Typha angustifolia* L.) dominated marsh at Dyke Marsh and the pumpkin ash (*Fraxinus profunda* [Bush] Bush) swamp forest surrounding it. Important micro-habitats for snails included under or inside rotting logs, under loose bark of fallen trees, and in leaf litter.

MATERIALS AND METHODS

Surveys lasting one to five hours were conducted in 2010 and 2011 during the following months: February (2 dates), March (6), April (8), May (7), June (8), July (4), August (4), September (4), October (3), and November (2). Surveys were conducted using 3x magnifying lenses to look under woody debris, rocks, leaf litter, loose bark of rotting fallen trees, and along the bases of concrete structures. Additionally, leaf litter samples were collected by filling one to three paper grocery bags (typically 14-18 l) at most sites, and each habitat type, including talus slopes in Turkey Run Park, slopes along Difficult Run, ravine forest in Great Falls Park, shell marl forests in Fort Washington and Piscataway parks, upland woods on Theodore Roosevelt Island, and Dyke Marsh swamp. Leaf litter samples were left in paper bags until dry, sieved in a hand spun centrifuge (pore sizes 5 x 2 mm to 5 x 20 mm), and examined under a dissecting microscope. In 2010, concurrent with this study, 500 ml cup pitfall traps were set to collect ground beetles. Bycatch in these cups often included snails that were added to the records for this study. Field notes were recorded for habitat types and locations of each collection.

Voucher specimens were collected for each species observed and to document new county or state records. Shells collected at NCPE are deposited at the Museum Resource Center (MRC) in Landover, Maryland. Shells collected at GWMP are deposited at Turkey Run Headquarters in McLean, Virginia.

New county and District records were determined by comparison with data in DeWitt (1952), Grimm (1971a), Beetle (1973), Dundee (1974), Hubricht (1985), and Steury & Steury (2011). State record determinations were based on these literature reviews, plus records provided by Perez & Cordeiro (2008), and queries of collection databases at Academy of Natural Sciences at Philadelphia (ANSP), Bailey-Matthews Shell Museum (BMSM), Carnegie Museum of Natural History (CMNH), Field Museum of Natural History (FMNH), Florida Museum of Natural History (FLMNH), National Museum of Natural History (NMNH), Santa Barbara Museum of Natural History (SBMNH), The Delaware Museum of Natural History (DMNH), The Ohio State University Museum of Biological Diversity (OSM), University of Michigan Museum of Zoology (UMMZ), and Yale Peabody Museum of Natural History (YPM).

Familial nomenclature and taxonomic order follow Bouchet & Rocroi (2005), except for Cionellidae, which follows Roth (2003). Generic and species names follow Perez & Cordeiro (2008) and Turgeon et al. (1998), and are listed alphabetically.

RESULTS AND DISCUSSION

At least 64 species (ten slugs and 54 snails) in 23 families were documented from 10 national park sites along the Potomac River near Washington, DC, including 10 non-natives (7 slugs, 3 snails). All of the latter are of European origin, except for *Paralaoma servilis* (New Zealand) and *Milax gagates* (Mediterranean region). *Paralaoma servilis* and *Zonitoides nitidus* were documented for the first time from Virginia and *Euconulus polygyratus* was confirmed for the state.

Sixty new county or District records were established (Table 1), including 22 species (eight non-

Table 1. Species (n=64) of land snails and slugs found in national park sites in the District of Columbia (DC), Charles (CH) and Prince Georges (PG) counties, Maryland, and Arlington (AR) and Fairfax (FA) counties, and the City of Alexandria (CA), Virginia. New county and city records are indicated by an asterisk (*). Species newly recorded from the District of Columbia and vicinity since Richards (1934) are marked with a dagger (†). Non-native species are marked with an exclamation point (!).

FAMILY	SPECIES	DC	MD		VA		
			CH	PG	AR	CA	FA
POMATIOPSIDAE	*Pomatiopsis lapidaria* (Say, 1817)	X	X*	X*	X	X	X
ELLOBIIDAE	*Carychium exiguum* (Say 1822)		X*	X*	X	X	X
	Carychium exile I. Lea, 1842			X*			X*
SUCCINEIDAE	†*Catinella vermeta* (Say, 1824)			X		X*	X*
	†*Novisuccinea ovalis* (Say, 1817)						X*
	†*Oxyloma* cf. *effusum* (Pfeiffer, 1853)	X*	X	X*		X*	X*
	Oxyloma cf. *subeffusa* Pilsbry, 1948	X					
CIONELLIDAE	*Cochlicopa lubrica* (Müller, 1774)			X		X*	
	†*Cochlicopa lubricella* (Porro, 1838)			X*			
PUPILLIDAE	*Pupoides albilabris* (C.B. Adams, 1841)			X			
STROBILOPSIDAE	*Strobilops aeneus* Pilsbry, 1926		X	X*			X
	Strobilops labyrinthicus (Say, 1817)						X
	†*Strobilops texasianus* Pilsbry & Ferriss, 1906			X			
VALLONIIDAE	*Vallonia excentrica* Sterki, 1893			X	X		X
VERTIGINIDAE	*Gastrocopta armifera* (Say, 1821)			X*			
	Gastrocopta contracta (Say, 1822)	X		X	X		X
	Gastrocopta corticaria (Say, 1816)			X			
	Gastrocopta pentodon (Say, 1821)			X			X
	Gastrocopta procera (Gould, 1840)			X			X*
	Gastrocopta tappaniana (C.B. Adams, 1842)	X		X	X*	X*	X*
	Vertigo milium (Gould, 1840)			X*			
	Vertigo ovata Say, 1822		X*		X*	X*	X*
	Vertigo pygmaea (Draparnaud, 1801)			X			X*
HAPLOTREMATIDAE	*Haplotrema concavum* (Say, 1821)			X			X
PUNCTIDAE	†!*Paralaoma servilis* (Shuttleworth, 1852)					X*	
	Punctum minutissimum (I. Lea, 1841)		X	X	X		X*
	†*Punctum smithi* Morrison, 1935			X			X
	Punctum vitreum (H.B. Baker, 1930)		X*	X*			X
DISCIDAE	*Anguispira alternata* (Say, 1816)	X	X	X			X
	†*Anguispira fergusoni* (Bland, 1861)	X		X	X*		X
	†!*Discus rotundatus* (Müller, 1774)	X					
HELICODISCIDAE	*Helicodiscus parallelus* (Say, 1817)	X		X	X		X
	Lucilla scintilla (R.T. Lowe, 1852)			X*			X*
GASTRODONTIDAE	*Striatura meridionalis* (Pilsbry & Ferriss, 1906)			X			X
	†*Striatura milium* (E.S. Morse, 1859)						X
	Ventridens ligera (Say, 1821)	X	X	X	X	X	X
	Ventridens suppressus (Say, 1829)			X	X		X
	Zonitoides arboreus (Say, 1816)	X	X	X	X	X	X
	†*Zonitoides nitidus* (Müller, 1774)			X*		X*	
EUCONULIDAE	*Euconulus dentatus* (Sterki, 1893)						X*
	Euconulus fulvus (Müller, 1774)						X*
	Euconulus polygyratus (Pilsbry, 1899)			X*			X*
	Guppya sterkii (Dall, 1888)			X			
ZONITIDAE	*Glyphyalinia indentata* (Say, 1823)			X	X		X
	†*Glyphyalinia luticola* Hubricht, 1966			X*			X*
	†*Glyphyalinia solida* (H. B. Baker, 1930)			X			X*
	Glyphyalinia wheatleyi (Bland, 1883)			X			X*
OXYCHILIDAE	!*Oxychilus draparnaudi* (Beck, 1837)	X		X		X*	

Table 1 (continued).

FAMILY	SPECIES	DC	MD		VA		
			CH	PG	AR	CA	FA
PRISTILOMATIDAE	*Hawaiia minuscula* (A. Binney, 1841)			X			X
LIMACIDAE	†!*Ambigolimax valentiana* (Férussac, 1823)				X*	X*	X*
	!*Limax maximus* Linné, 1758			X		X*	X*
MILACIDAE	†!*Milax gagates* (Draparnaud, 1801)						X*
AGRIOLIMACIDAE	*Deroceras laeve* (Müller, 1774)	X		X	X	X	X
	†!*Deroceras reticulatum* (Müller, 1774)				X*	X*	
ARIONIDAE	†!*Arion hortensis* Ferussac, 1819					X*	
	†!*Arion intermedius* (Normand 1852)			X*			X*
	†!*Arion subfuscus* (Draparnaudi, 1805)			X		X	X
PHILOMYCIDAE	†*Megapallifera mutabilis* (Hubricht, 1951)						X*
	†*Philomycus carolinianus* (Bosc, 1802)		X	X			X
POLYGYRIDAE	*Mesodon thyroidus* (Say, 1816)	X	X	X	X		X
	Neohelix albolabris (Say, 1816)						X
	†*Stenotrema barbatum* (Clapp, 1904)			X	X*		X
	Triodopsis juxtidens (Pilsbry, 1894)	X		X	X	X	X
	Xolotrema denotatum (Férussac, 1821)		X*	X*			

native) added to the regional fauna since the work of Richards (1934). Thirty-four species were found only on the Coastal Plain as opposed to five only in the Piedmont. A total of 22 species was found only in dry to mesic upland forests, 12 only in open or forested wetlands, eight only in dry to mesic open areas, and 22 were found in more than one habitat type. Seven species (10.9%) were documented only by the presence of shells. The half life of empty shells in habitats similar to these can extend up to 11.5 years (Pearce, 2008b), suggesting recent occurrences. Fifteen species were found in the District of Columbia, 51 in Maryland (49 Prince Georges Co., 13 Charles Co.), and 56 in Virginia (19 Arlington Co., 19 City of Alexandria, 50 Fairfax Co.). Most of the new county records are probably not an indication of recent range extensions but more likely further evidence that distributions of land snails are poorly known. The historic forts and Endicott batteries at Fort Washington and Fort Hunt proved to be especially important sites for land snail species richness. The now crumbling calcareous mortar and concrete that was used to construct these sites seemed to create ideal habitat for snails preferring calcareous, mesic to xeric, open areas, while the developing, thin, soil layer over the concrete basal areas, often covered by thin leaf litter proved to be a favored habitat for many species of snails. The calcareous shell marl ravine forests of Fort Washington and Piscataway parks contained a noticeably higher density of land snails than the more acidic woodlands on the Virginia side of the Potomac, not surprisingly since snails are known to be more abundant and diverse in calcium-rich areas (Hotopp, 2002).

Several species reported here involve challenging identifications and for some the taxonomy is uncertain. Smaller zonitid, pristilomatid, and euconulid snails in genera such as *Glyphyalinia*, *Hawaiia*, and *Euconulus* possess shells that are notoriously difficult to identify. Identification of many succineid snails requires genetic analysis (Hoagland & Davis, 1987), which was not performed. The material collected during this study will serve as a baseline for future investigations into the land snail fauna of areas along the Potomac River near the District of Columbia.

LIST OF SPECIES

CAENOGASTROPODA

POMATIOPSIDAE

Pomatiopsis lapidaria (Say, 1817) – (DM, FW [Swan Creek {SC} floodplain], JP, LH, PP [Bull Cove {BC} marsh, Accokeek Creek {AC} swamp, Wharf Road {WR} swamp], RI, RR). This is a common amphibious snail of tidal marshes, swamps, and creek banks on the Coastal Plain. It was generally found under moist logs within these habitats but one live snail was captured on 14 April 2010 in a pitfall trap in second growth woodland 25 m from the shore of Little Hunting Creek. Live animals were observed between 14 April and 18 October 2010 and as early as 19 February 2011. It was

commonly associated with *Carychium exiguum* and *Catinella vermeta*. Örstan & Pearce (2011) also recently reported it from the southern shore of Oxon Cove in Prince Georges County, Maryland. DeWitt (1952) reported this species from "Fox's Ferry," present day Oxon Cove.

PULMONATA

ELLOBIIDAE

Carychium exiguum (Say, 1822) – (DM, FW [SC floodplain], JP, LH, PP [BC, WR swamp], RR. This snail was found only in tidal Coastal Plain wetlands, under moist vegetative debris in swamps, and along marsh edges and creek banks. Live animals were observed between 18 April and 18 October 2010 and as early as 19 February 2011. On 17 July 2010, live animals were found under a moist log 0.7 m x 0.3 m at the edge of fringe marsh along Swan Creek. Also under this log were associated species *Gastrocopta contracta*, *P. lapidaria*, *Strobilops aeneus, Ventridens ligera*, *Vertigo milium*, and *Zonitoides arboreus*.

Carychium exile I. Lea, 1842 – (FW [Battery Emory {BE}, shell marl ravine forest {SM}], PP [SM], TR). This is an uncommon but locally abundant snail within the study area. It was found at four shady, deciduous forested sites, with seasonally moist leaf litter, on talus slopes, in upland second growth woodland, and mature forested ravines, in both the Piedmont and Coastal Plain. A common associate was *Punctum minutissimum*. A well-sorted leaf litter sample measuring 15.3 l collected on 4 August 2010, from forested talus slopes in Turkey Run Park contained at least 152 *C. exile*, 141 *P. minutissimum*, 17 *G. contracta*, 17 *Euconulus fulvus*, five *Z. arboreus*, three *Punctum vitreum*, one *Glyphyalinia indentata*, one *Punctum smithi*, one *Stenotrema barbatum*, and one *V. ligera*. Live animals were observed between 2 June and 17 October 2010. Live animals observed 4 August 2010, included juveniles of 2.5 whorls.

SUCCINEIDAE

The taxonomy of this family is not well understood and the taxon concepts presented below are based largely on those of previous studies (Grimm, 1971a; Hubricht, 1985) in the vicinity of Washington, DC. In addition to the four taxa discussed below, other species may be present in our area but could not be assigned to any known described species. Images of live animals and a comparison of shell characters are presented in Figs. 1-5.

Catinella vermeta (Say, 1829) – (DM, JP, LH, PP). This snail was found at four wetland sites on the Coastal Plain. It was common at one site in Dyke Marsh under logs in freshwater, tidal, *Typha angustifolia* marsh on 14 April 2010. One live animal was observed in freshwater, tidal, fringe marsh along Little Hunting Creek on 3 June 2010. Fourteen *C. vermeta* were found under woody debris on a tidal shore of Jones Point on 8 April 2010 and the species was observed there again on 15 June 2011. A small population was found under woody debris in freshwater, tidal, swamp forest along Piscataway Creek on 19 February 2011. Although 23 species of *Catinella* have been reported from the United States (Perez & Cordeiro, 2008), only three of these, *C. hubrichti* Grimm, *C. oklahomarum* (Webb), and *C. vermeta* have been documented from Virginia or Maryland (Hubricht, 1985; Perez & Cordeiro, 2008). Grimm (1960) provided a comparison of these three species showing a more pronounced spire in *C. vermeta* due to an additional whorl. According to Hubricht (1985), *C. hubrichti* is a snail of brackish marshes that climbs marsh vegetation and *C. oklahomarum* is found in upland pine woods. The only *Catinella* found during this survey was the higher spired, freshwater, wetland species, which was never observed climbing vegetation, and thus we attribute it to *C. vermeta* (Fig. 2).

Novisuccinea ovalis (Say, 1817) – (TR). On 17 June 2010, 34 live *N. ovalis* were found at Turkey Run Park spread over an area of 9 by 9 m located on a sandy floodplain 25 m from the bank of the Potomac River under the canopy of a large *Juglans nigra* L. Twelve snails were observed climbing the herb *Laportea canadensis* (L.) Weddell, nine were on *Asarum canadense* L., and five on *Geranium maculatum* L. Two were observed climbing the woody vine *Menisperum canadense* L. and six were observed on the woody shrub *Lindera benzoin* (L.) Blume. Associated snails at this site were *V. ligera*, climbing *Asarum canadense*, and *Mesodon thyroidus*, climbing *Lindera benzoin*. Pilsbry's (1948) description of this species as "larger and more inflated than any other (succineid) of the region" clearly diagnoses this species. Although the coloration of the animal is variable (see Pilsbry, 1948, Fig. 430a and 430b), the animals observed in this population (Fig. 3) were of a uniform pale color as shown in Pilsbry's Fig. 430a.

Oxyloma cf. *effusum* (Pfeiffer, 1853) – (DM, FW [SC fringe marsh], JP, LH, PP [BC, Accokeek Marsh], RI). This is the most common succineid found within the survey area. It occurred only in freshwater, tidal, *T. angustifolia* marshes and surrounding swamps where it

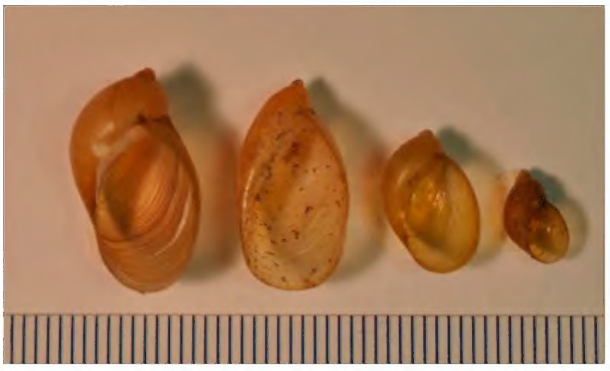

Fig. 1. From left to right: shells of *Novisuccinea ovalis* (Turkey Run Park, 17 June 2010; 18.2 mm), *Oxyloma* cf. *effusa* (Dyke Marsh, 9 September 2010; 18 mm), *Oxyloma* cf. *subeffusa* (Theodore Roosevelt Island, 15 June 2011; 11.5 mm), and *Catinella vermeta* (Dyke Marsh, 14 April 2010; 7.8 mm). Hash marks are in mm.

Fig. 2. *Catinella vermeta*, Jones Point Park, City of Alexandria, Virginia, 15 June 2011.

Fig. 3. *Novisuccinea ovalis*, Turkey Run Park, Fairfax County, Virginia, 17 June 2010.

was easily found climbing high on the leaves and stems of *Typha* and *Sagittaria*, or under woody debris during cooler months. Live animals were observed between 14 April and 18 October 2010 and on 17 March 2011. Eggs probably hatch in late August or early September since a live animal with a 1.3 mm shell was collected

Fig. 4. *Oxyloma* cf. *effusa*, Dyke Marsh, Fairfax County, Virginia, 15 June 2011.

Fig. 5. *Oxyloma* cf. *subeffusa*, Theodore Roosevelt Island, District of Columbia, 15 June 2011.

on 9 September 2010. Descriptions of *O. effusum* and its habits by Grimm (1971a) fit well with observations of this species (Fig. 4) in the study area. Perez & Cordeiro (2008) reported 16 species of *Oxyloma* from the United States, including two (*O. effusum* and *O. subeffusm* Pilsbry) from Maryland and Virginia. Their inclusion of *O. retusum* (I. Lea) for Virginia is probably based in error on Hubricht's (1985) record from bordering Pendleton County, West Virginia. This is a wide-ranging species north of Virginia, extending across the northern tier of states west to California, and south to New Mexico, southern Illinois, and West Virginia, whereas *O. effusum* is a species of the Atlantic Coast from New Jersey to Florida (Hubricht, 1985; Perez & Cordeiro, 2008). Grimm (1971a) stated that records of *O. decampi gouldi* Pilsbry (synonymized with *O. retusum* by Hubricht, 1985, as suggested by Grimm, 1971a) from Maryland were based on misidentifications of *O. subeffusm* or *Catinella hubrichti* Grimm. To further complicate matters, Grimm (1981) suggested *O. d. gouldi* is equivalent to *O. verrilli* (Bland), a species Hubricht (1985) synonymized with *O. groenlandica* (Möller), which is

known from Iceland, Greenland, and Canada. Örstan (2010) stated "some uncertainty" about his record of *O. retusum* from Montgomery County, Maryland, 64.4 km north of Dyke Marsh. Although there are some similarities in the Montgomery County and Dyke Marsh *Oxyloma* populations (both apparently hatch young in late August or early September), there were also notable differences (the longest shell of any animal measured from Montgomery County was 14 mm and the longest shell found by September was 9 mm, while at Dyke Marsh, shells as long as 18 mm were observed in September). Pilsbry (1948) listed a maximum length of 16.3 mm for *O. retusum* and 19.5 mm for *O. effusum*. We believe all *Oxyloma* found in the survey area are best attributed to *O. effusum* based primarily on previously documented ranges (Hubricht, 1985) and shell length. Additionally, the broader aperture shape of Dyke Marsh *Oxyloma* more closely approximate Pilsbry's (1948) Fig. 423d of *O. effusum* from New Jersey than it does the narrower aperture of *O. retusum* from Illinois in Fig. 421a. A detailed genetic analysis of *Oxyloma* from the District of Columbia area is warranted.

Oxyloma cf. *subeffusa* Pilsbry, 1948 – (RI). This snail was observed only on Theodore Roosevelt Island on 24 March and 15 June 2011, scattered under moist woody debris in a tidal swamp and moist woodland between a small marsh and the Potomac River. Although Grimm (1971a) described the ground color of *O. subeffusa* as pale gray, Pilsbry's (1948) description of its ground color as very pale gray or faintly yellowish better describes the specimens from Theodore Roosevelt Island. The form, color, and size of the shell, and the pattern and color of our material (Fig. 5), match exactly Fig. 418a of Pilsbry (1948). Both Grimm (1971a) and Hubricht (1985) mentioned that *O. subeffusa* does not climb vegetation, which is consistent with our observations. *O. subeffusa* is a globally rare (G3) snail found only along the Atlantic Coast from southern Virginia to New Jersey (Hubricht, 1985). It is ranked as an S1 "extremely rare and critically imperiled" species in Virginia (Roble, 2013). Pilsbry (1948) mentioned a collection from Washington, DC without citing a specific locality. Theodore Roosevelt Island would be the westernmost site known in the distribution of *O. subeffusa*.

The only other succineid species previously reported for Maryland and Virginia are *Succinea campestris* Say, a species associated with dry, beach dune grasses, and *S. wilsoni* I. Lea, a high-spired species of brackish marshes. Additionally, *S. indiana* Pilsbry, a species of dry, sunny, bare ground, has been recorded from Maryland, but not Virginia. Non-indigenous succineid species, such as *Oxyloma salleana* (Pfeiffer) from the Mississippi River drainage or the European *Succinea putris* (L.) which has been reported from sites as near as northern Pennsylvania (Pearce, 2008a), potentially could also occur in the survey area. Reports of the federally threatened *Novisuccinea chittenangoensis* (Pilsbry) from southwestern Virginia, in Tazewell County, by Hubricht (1985) and cited by Perez & Cordeiro (2008) were refuted by Hoagland & Davis (1987) and upheld by Niver (2010).

CIONELLIDAE

Cochlicopa lubrica (Müller, 1774) – (FW [Battery Humphries {BH}, Battery Wilkin {BW}], JP, OC). Live snails were found between 17 April and 15 June in dry to seasonally mesic, sunny, open locations with little or no vegetation on thin calcareous soils over concrete and often under shallow leaf litter and rarely on moist tidal shores. The two *Cochlicopa* species found during this inventory have been shown to be distinct in Europe based on allozyme patterns and shell variables (Armbruster and Schlegel, 1994; Armbruster, 1995). Until North American forms are similarly studied, we accept the separation proposed by Armbruster (1995) of mature shells with a maximum shell diameter < 2.2 mm to be *C. lubricella* and shells with a diameter > 2.3 mm to be *C. lubrica*. A shell was found in a mouse nest on a capped landfill on the northern shore of Oxon Cove, a few meters from the District of Columbia line. The Oxon Cove and Jones Point shells were larger (5.9-6.2 mm long, 2.6-2.7 mm wide) than any shell found at Fort Washington (largest 5.1 mm long, 2.4 mm wide). Grimm (1971a) stated that this species is synanthropic east of Garrett County, Maryland.

Cochlicopa lubricella (Porro, 1838) – (FW [BW]). Shells were found only at Battery Wilkin in association with the more common *C. lubrica*.

PUPILLIDAE

Pupoides albilabris (C.B. Adams, 1841) – (FW [BE, Battery Meigs {BM}, BW, Fort Washington {fw}]). This snail was observed only on the Coastal Plain where it preferred dry to seasonally mesic, sunny, open locations with little or no vegetation on thin circumneutral soils over concrete and often under shallow leaf litter. It was common only at Battery Wilkin (live snails on 17 July 2010), uncommon at Battery Meigs, and rare at Fort Washington and Battery

Emory. Shells found at Battery Emory were in shady, second growth forest.

STROBILOPSIDAE

Strobilops aeneus Pilsbry, 1926 – (DM, FW [BE, BW, SC floodplain forest], GF, LH, PP [AC swamp, SM], TR). This was a common snail within the survey area generally found under loose bark of fallen trees in woodlands or swamps, but also occasionally found in leaf litter. Shells were rarely found at dry, open sites. Live snails were observed between 5 March and 13 November.

Strobilops labyrinthicus (Say, 1817) – (LH). The lone animal was found on 3 June 2010 in a moist log on the bank of Little Hunting Creek in association with *S. aeneus*. Hubricht (1985) recorded it mostly from western Virginia, and Grimm (1971a) documented it in Maryland only from three northwestern counties, but Norden (2008a) added Montgomery County. It is likely rare on the Virginia Coastal Plain.

Strobilops texasianus Pilsbry & Ferriss, 1906 – (FW [BM, BW]). This is a rare snail in the survey area (only shell material was found), recorded only on the Coastal Plain at dry, open sites associated with historic Endicott batteries and forts. The shell sculpture differences between *S. texasiana* and *S. labyrinthicus* are subtle. Pilsbry (1948) separated them by the coarseness of the ribbing, calling *S. labyrinthicus* "finely ribbed" and *S. texasiana* "coarsely ribbed," and noted that *S. labyrinthicus* matures at 1.7-1.8 mm high while *S. texasiana* may be as high as 2.0 mm. Burch (1962) was slightly more specific, and referred to ribbing on the base of the shell as "absent or poorly developed" in *S. labyrinthicus* and "well developed" in *S. texasiana*. Our specimen of *S. labyrinthicus* measured 1.8 mm high and had 41 ribs on the base that became almost obsolete near the aperture, while our most characteristic *S. texasiana* specimen was 1.9 mm high, had 31 ribs on the base, and possessed noticeably higher ribs on the spire.

VALLONIIDAE

Vallonia excentrica Sterki, 1893 – (FH, FW [BH, BM, BW, fw], RR). This is a locally common snail typically found in dry to mesic, open, grassy, sometimes mossy, sites on the Coastal Plain along the base of concrete or mortared walls of historic forts and batteries. It was the most commonly observed snail at the base of the walls of Fort Washington. A shell was found at the edge of a marsh at Roaches Run. Live snails were observed only on 17 April 2010.

VERTIGINIDAE

Gastrocopta armifera (Say, 1821) – (FW [BW, fw]). This is the largest of the *Gastrocopta* species found during the survey. It occurred at only two sites (both on the Coastal Plain) in dry to seasonally mesic, sunny, open locations with little or no vegetation, except turf grass or moss, on thin calcareous soils, often over concrete and under shallow leaf litter. Live snails were found between 17 April and 17 July 2010.

Gastrocopta contracta (Say, 1822) – (DM, FF, FH, FW [BE, BM, Battery Smith {BS}, BW, fw, SC floodplain forest, SM,], Gulf Branch [GB], GF, RI, TR). This is by far the most common *Gastrocopta* species documented within the study area. It was found at nearly every site and in a wide variety of habitats from dry, sunny, open sites, to leaf litter in shady ravine forests, and under loose bark of logs in swamps, on both the Coastal Plain and Piedmont. Live animals were observed between 17 April and 7 October 2010.

Gastrocopta corticaria (Say, 1816) – (FW [BE, fw]). This was the rarest *Gastrocopta* within the survey area, documented only by two shells. Both were found at calcareous Coastal Plain sites created by the presence of forts or Endicott batteries constructed between 1824 and 1903. Typically thought of as a forest species found on logs or tree trunks, the presence of a shell at the base of a wall of Fort Washington, an open, dry to mesic, calcareous, area surround by turf grass, is uncharacteristic for this species (Norden, 2007), which may indicate that it was moved to this location.

Gastrocopta pentodon (Say, 1821) – (FH [Battery Robinson {BR}, Battery Sater {BSa}], FW [BE, BW]). This snail was uncommon but locally abundant. Typical habitat included dry, open, sunny sites such as Battery Robinson, which was completed in 1904. Live snails were observed between 18 July and 17 October 2010. Some forms of the shell of this species can closely approximate those of *G. tappaniana*. The methods of Pearce et al. (2007) and Nekola & Coles (2010) were used to distinguish between them. However, within the survey area, *G. pentodon* was found only in dry to mesic upland habitats, and resembled *G. p.* form *gracilis* Sterki of Vanatta & Pilsbry (1906), which has five teeth and is subcylindric, whereas *G. tappaniana* was typically found in wetlands, is broader, and always has more than five teeth.

Gastrocopta procera (Gould, 1840) – (FH [BSa], (FW [BH, BM, BW, fw]). This species was found only in association with forts and batteries on the Coastal Plain and always in low abundance. It was most common at Battery Humphries where three shells were found. Live snails were observed between 17 April and 16 June 2010, climbing on concrete and mortared stone walls.

Gastrocopta tappaniana (C.B. Adams, 1842) – (DM swamp, FW [BW], JP, LH, PP [AC swamp, WR swamp], RI, RR). This species was uncommon within the survey area, generally found under moist logs in swamps on the Coastal Plain, however two shells were found at a dry upland site at Battery Wilkin. Live snails were found between 19 February and 7 October. For identification notes, see *G. pentodon*. Juveniles with developing dentition were found on 7 October 2010 in Dyke Marsh Swamp. The angulo-parietal and columellar lamellae are the first to form in this species. It was associated with *Vertigo ovata* at Dyke Marsh.

Vertigo milium (Gould, 1840) – (FW [BE, BM, BW, SC floodplain], PP [WR swamp]). This tiny snail was found in a variety of Coastal Plain habitats, including second growth woodland, dry, open sites, swamps, and shores. It was most common in second growth woodland at Battery Emory where 68 shells and a few live animals were found on 17 October 2010 in a leaf litter sample measuring 17.85 l.

Vertigo ovata Say, 1822 – (DM, JP, PP [BC]), RR). Live specimens were found under loose bark of rotting, fallen trees, under wood debris, climbing moist, shaded, fallen logs, and in wet leaf litter. Collection dates ranged from 17 March to 7 October.

Vertigo pygmaea (Draparnaud, 1801) – (FH [BSa], FW [BM, BW]). This species was found (mostly as shells) only on the Coastal Plain at dry, open Endicott battery sites. A live immature snail was found in Fort Hunt Park at Battery Sater on 16 June 2010.

HAPLOTREMATIDAE

Haplotrema concavum (Say, 1821) – (Claude Moore Farm, FW [BE, SM], GF, PP, TR). This uncommon, omnivorous snail was found at both Piedmont and Coastal Plain sites but was most numerous in shell marl ravine forest on the Coastal Plain, where the only live animal was found on 19 September 2010 under a rotting log.

PUNCTIDAE

Paralaoma servilis (Shuttleworth, 1852) – (JP) (Fig. 6). During 1.5 hours of search effort on 17 March 2011, 23 live snails and eight shells were found under woody debris deposited by storm tides along the western shore of Jones Point. Associated species included *C. exiguum*, *C. vermeta*, *Deroceras laeve*, *Deroceras reticulatum*, *P. lapidaria*, and *V. ligera*. This species is native to New Zealand (Brooks, 1999) and possibly Australia (Price & Webb, 2006) but has been introduced to North and South America, Europe, and the Pacific Islands. In western North America it was long mistaken as a native species described as *Punctum conspectum* (Bland) (Pilsbry, 1948). It is easily distinguished from the *Punctum* species in the survey area by its larger size (almost twice the diameter) and higher, more irregularly spaced ribs on the last whorl. This is the first record for Virginia and to our knowledge the first published record for the eastern United States (Dundee, 1974; Robinson & Slapcinsky, 2005; Perez & Cordeiro, 2008). It was also recently collected in Washington, DC outside the study area (CMNH 121988, "across street from 4100 Cathedral Ave.", Pearce, 8 March 2012).

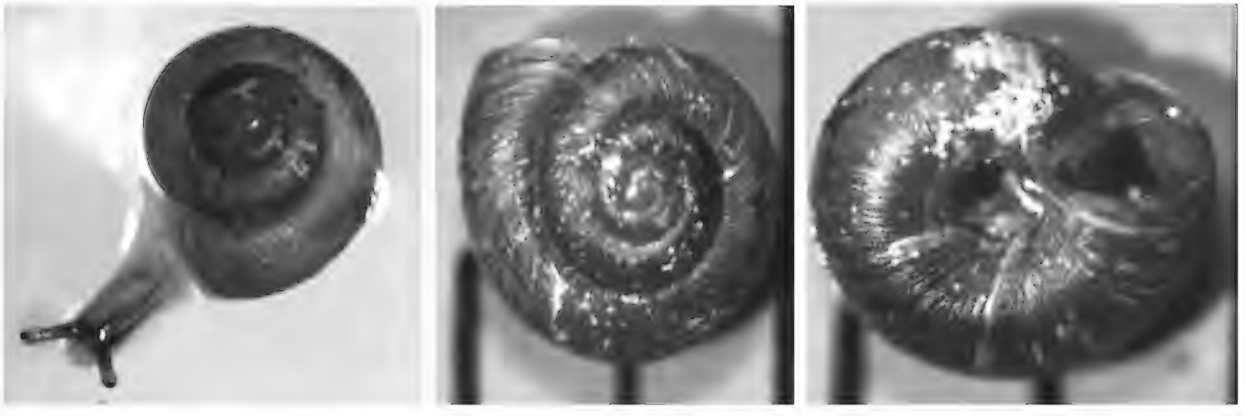

Fig. 6. *Paralaoma servilis*. Left to right: Live specimen, 17 March 2011, Jones Point Park, City of Alexandria, Virginia; dorsal view of empty shell; ventral view of empty shell. Hash marks are in mm.

Fig. 7. *Punctum* species found in the study area from left to right, *P. minutissimum* (Fairfax County, VA, Turkey Run Park, 4 August 2010), *P. smithi* (Prince Georges County, MD, Fort Washington, 19 June 2010), and *P. vitreum* (Prince Georges County, MD, Fort Washington, 17 October 2010).

Punctum minutissimum (I. Lea, 1841) – (FW [BE, SM], GF, PH, PP, TR). This is probably a very common snail in the survey area but due to its minute size it was detected only in moist leaf litter samples from deciduous woodlands on both the Coastal Plain and Piedmont. Live animals were observed on 19 June and 4 August 2010 and 17 March 2011. The three *Punctum* species found during this survey are fairly distinctive when compared side by side (Fig. 7). *P. smithi* is the smallest at maturity, possesses at least one lamella on the base inside the aperture, and has the palest and most transparent shell. *P. minutissimum* lacks lamellae and has closely spaced and regularly occurring riblets of equal height, and *P. vitreum* is the darkest in life and possesses higher major riblets interspaced with 4 to 8 minor riblets.

Punctum smithi Morrison, 1935 – (FW [BE, SM], GF, PP [SM], TR). The habitat and distribution of this species were the same as for *P. minutissimum* but it was slightly more common in shell marl forest on the Coastal Plain than in the Piedmont. It was also found on hummocks in Great Falls Swamp. These two species were often found together, but rarely in equal numbers (e.g., Fort Washington Park leaf litter sample: 124 *P. smithi*, 4 *P. minutissimum*,; Turkey Run Park leaf litter sample: 141 *P. minutissimum*, 1 *P. smithi*). Live animals were observed on 19 June and 4 August 2010.
A previously undescribed growth form (Fig. 8) was found at three sites in Fort Washington Park occurring with typical *P. smithi*. It is easily distinguished from typical *P. smithi* by possessing two lamellae within the aperture, one at the normal position and a more interior one. Although variation in the dentition of *P. smithi* has been noted (Hubricht, 1951), it has been in reference to the length and shape of a single basal lamella rather than the number of lamellae. The type description for this species (Morrison, 1935), and others since that time (Pilsbry, 1948; Burch, 1962; Hubricht, 1974), mention only one basal lamella just inside the aperture. Collections of *P. smithi* at Fort Washington Park indicate that 5.8% of the population is the bidentate form.

Fig. 8. *Punctum smithi*, form with two lamellae, found at three sites in Ft. Washington Park, Prince Georges County, Maryland. Arrows indicate locations of two lamellae.

Punctum vitreum (H.B. Baker, 1930) – (FW [BE], PP [SM], TR). This was the least common of the *Punctum* species in the survey area. It was more common on the Coastal Plain but found at only 3 forested sites in leaf litter. Live animals were observed on 17 October and 13 November 2010. In the Piedmont, it was represented by 3 empty shells found in leaf litter from forested talus slopes in Turkey Run Park.

DISCIDAE

Anguispira alternata (Say, 1816) – FW [BE, BS, Battery White {BWh}, fw, SM], GF, PP, RI). Found at most woodland sites in the Piedmont and Coastal Plain sections of the survey area and also in dry, open areas at historic batteries. It was most common in shell marl ravine forest in Fort Washington Park. All of the shells within the survey area have a low spire and angular periphery characteristic of Pilsbry's (1948) form *angulata*. By comparison, Norden (2008a) reported that only 40% of *A. alternata* shells on Plummers Island, Maryland, on the opposite shore from the study area, exhibited an angular periphery. Animals of this species have orange mucus.

Anguispira fergusoni (Bland, 1861) – (GF, PH, PP, RI, TR). Surprisingly, this species was scarcer on the Coastal Plain than in the Piedmont area of the survey. Hubricht (1985) asserted that *A. fergusoni* is an inhabitant of the Atlantic Coastal Plain that has followed floodplains up into the Piedmont region. Pilsbry (1948) described it as being found on the Coastal Plain but as being most common at or near the Fall Line. The only Coastal Plain animals found during this survey were on Theodore Roosevelt Island, just below the Fall Line, on 31 March 2010, and in shell marl ravine forest in Piscataway Park, where it was associated with the typically montane species *Xolotrema denotatum*. It was much more common in the Piedmont, in shady, oak dominated woodland, usually under stones or fallen limbs. On 22 June 2010, one snail in Great Falls Park was found climbing the trunk of *Carpinus caroliniana* Walt. to 3 m along the River Trail south of Sandy Landing. The periphery of this shell is rounded and the mucus is clear.

Discus rotundatus (Müller, 1774) – (OC). This introduced European snail was documented only on a landfill at Oxon Cove in the District of Columbia (Steury & Steury, 2011). Three shells and 51 live snails were found.

HELICODISCIDAE

Helicodiscus parallelus (Say, 1817) – (FH, FW [BE, BWh, fw, SM], GF, LH , PH, PP [AC swamp, SM], RI). This species was widespread but uncommon in the study area. The most shells found at one site was seven in a 13.77 l leaf litter sample from shell marl forest in Fort Washington Park. It seems to be a habitat generalist occurring in forests, swamp hummocks, and drier, open sites, under bark, and in leaf litter. Live animals were observed between 16 June and 17 October 2010 and on 5 March 2011.

Lucilla scintilla (R.T. Lowe, 1852) – (FH, PP [SM]). *Lucilla inermis* H.B. Baker was recently synonymized with *L. scintilla* (Horsák et al., 2009). This was a rare snail in the survey area, represented only by single shells found at Battery Sater in Fort Hunt Park and in mature shell marl ravine forest along Accokeek Creek in Piscataway Park. *Hawaiia minuscula* is similar in appearance, but these species can be distinguished under magnification by differences in shell sculpture, (uneven, distinct, growth wrinkles in *H. minuscula* compared to the smooth, paraffin or porcelain-like surface of *L. inermis*, which may have a few growth wrinkles near the aperture). We used Horsák et al. (2009) to distinguish *L. scintilla* from *L. singleyana* (Pilsbry), which has been documented from near the study area.

GASTRODONTIDAE

Striatura meridionalis (Pilsbry & Ferriss, 1906) – (FW [BE], GF, PP [SM], TR). This was a widespread but uncommon snail found at four sites in leaf litter of deciduous woods and also on hummocks in Great Falls Swamp.

Striatura milium (E.S. Morse, 1859) – (GF, TR). This snail was found only in the Piedmont section of the survey area in leaf litter in deciduous forested ravines. It is rare (S1S3) in the Commonwealth (Roble, 2013). These sites are near the southernmost known for this species. Live snails were observed on 19 September 2010. The embryonic whorl of *S. milium* lacks the spiral lirae of *S. meridionalis*.

Ventridens ligera (Say, 1821) – (DI, DM, FF, FW [BE, BH, BM, BS, BW, BWh, fw, SC floodplain, SM,], GF, JP, LH, OC, PH, PP, RI, TR). This snail and *Zonitoides arboreus* are the most easily found snails within the survey area. It occurred at most upland sites in both moist and dry situations, and rarely in wetlands. One individual was found at the top of a *Pycnanthemum tenuifolium* Schrad., 80 cm above the sandy substrate, at Sandy Landing, in Great Falls Park.

Ventridens suppressus (Say, 1829) – (FH, FW [BE, BM, BW, fw], GF, LH, PH, TR). This was a widespread but uncommon snail within the survey area. Solitary individuals were typically found at the base of large rocky outcrops or boulders in deciduous woods, but an aggregation of 21 shells and nine live animals was found at Battery Wilkin, a dry open site, on 17 April 2010. Eight of these shells were adults with one denticle and 22 were multi-denticled juveniles. A live snail was also found on a hummock in Great Falls Swamp. Live snails were observed between 17 April and 19 September 2010. *Ventridens virginicus* (Vanatta), a similar species that has been reported from just west of the survey area, differs from *V. suppressus* in having two denticles at maturity, one (usually bifid) along the columellar margin and the other lamella relatively high on the palatal margin. At maturity, *V. suppressus* has one uncleaved denticle located at the base of the columellar margin, and subadults have a lamella relatively low on the palatal margin. There was no evidence of *V. virginicus* within the survey area.

Zonitoides arboreus (Say, 1816) – (DM, FF, FH, FW [BE, BM, BW, BS, fw, SM, SC floodplain], GB, GF,

Fig. 9. *Zonitoides nitidus*, live specimen, 17 March 2011, Jones Point Park, City of Alexandria, Virginia.

JP, LH, PH, PP, RI, TR). This is the most commonly observed snail within the survey area. It is found in all habitats (deciduous forests, swamps, and dry open sites) under logs, loose bark, and in leaf litter, but it is probably most common in upland deciduous woods.

Zonitoides nitidus (Müller, 1774) – (DI, JP, PP [WR floodplain forest]). This snail (Fig. 9) was found at three sites during the survey, including a live adult and two live juveniles found on 28 July 2010 along the bank of the Potomac River under woody storm debris left by high tides near a small freshwater marsh on Daingerfield Island. On 19 February and 17 March 2011, it was found in very similar habitat near Wharf Road at Piscataway Park and at Jones Point, respectively. Other records of this snail along the Potomac River, from the northwest, are limited to Garrett County, Maryland, a distance of 273 km. Richards (1934) reported a collection from Baltimore, 64 km northward. The largest shell measured 6.7 mm at the largest diameter. In comparison to Z. *arboreus*, *Z. nitidus* is larger at maturity (6-7 mm), has a higher spire, possesses a more convex base and rounder aperture, and lacks spiral striation on the shell. In life, *Z. nitidus* is darker, and the shell is more transparent and amber colored. This is the first record for Virginia and the Maryland site is the southernmost record for the East Coast of North America.

EUCONULIDAE

Euconulus dentatus (Sterki, 1893) – (FH [BR], GF). This snail was found at only two sites, including a dry open site on the Coastal Plain (1 shell) and a small colony on 15 September 2010 in the Piedmont in moist leaf litter near the mouth of an unnamed drainage leading to Difficult Run. This species is easily distinguished from the next two, by possessing a few, low lamellae, elongate in a radial direction, in the base of the last whorl.

Euconulus fulvus (Müller, 1774) – (TR). This species was found only in leaf litter on a forested talus slope in the Piedmont, the easternmost known locality in Virginia. J. Slapcinsky identified these specimens through comparisons with material at FLMNH, noting the larger and relatively flatter, more loosely coiled species as *E. fulvus*. A genetic study of *Euconulus* is desirable because the shells and genitalia are relatively simple and their small size makes detailed anatomical work difficult.

Euconulus polygyratus (Pilsbry, 1899) – (FW [SM], GF, PP [SM]). This species was found in both the Piedmont and Coastal Plain at a total of three sites. All collections were from leaf litter, including two sites in shady, deciduous forested ravines. At Great Falls it occurred in association with *E. dentatus*. Three additional lots of *E. polygyratus* from Fairfax County were found at FLMNH (299067 & 299088; Popes Head Road at Popes Head Creek and Occoquan Regional Park, both J. Slapcinsky) and CMNH (85289; Mt. Vernon, G.H. Clapp).

Hubricht (1985) and Perez & Cordeiro (2008) did not list *E. polygyratus* from Virginia, but Beetle (1973), without citing specific specimens or localities, recorded this species from Alleghany and Pulaski counties. Specimens identified as *Euconulus chersinus* (Say), a species with shell morphology very similar to that of *E. polygyratus*, were located at FMNH, collected by L. Hubricht between 1945 and 1972 from western (Giles Co.) and southern (Pittsylvania and Sussex counties), Virginia. However, these records did not appear in the mapped distribution of this species he compiled (Hubricht, 1985). In that paper, Hubricht placed more than 440 km between his records of *E. polygyratus* in Frederick County, Maryland, and *E. chersinus* and *E. trochulus* (Reinhardt) in northeastern Tennessee and southwestern Virginia, respectively.

Guppya sterkii (Dall, 1888) – (FW [SM], PP [SM]). This minute species was represented within the survey area by one live snail collected from leaf litter on the north side of Fort Washington Park on 17 October 2010 and by five live animals found along Accokeek Creek on 30 April 2011.

ZONITIDAE

Glyphyalinia indentata complex (Authors) – (FW [BE, BH, SM], GF, LH, PH, PP, RR). This species complex

was found throughout the survey area (all shells except one live snail on 24 August 2010) in upland leaf litter or under rotting logs, but not in high abundance. Two shells were found on hummocks in Great Falls Swamp. In dry to mesic, upland, shell marl forest in Piscataway Park, shells with forms attributable to this group ranged in color from transparent pinkish or pale brown, to clear (when young), to opaque and yellowish brown. The degree of spiral striation was also variable. This taxon complex is actually a series of undescribed anatomical species, with few or no shell differences (Hubricht, 1985). Of *Glyphyalinia* species having a minute umbilicus, *G. cryptomphala* can be separated by having a tongue-shaped callus covering the umbilicus. Five species (*G. junaluskana* [Clench & Banks], *G. sculptilis* [Bland], *G. pecki* Hubricht, *G. picea* Hubricht, and *G. latebricola* Hubricht) can be separated by having more numerous radiating grooves, 43-82 grooves on the last whorl. *Glyphyalinia luticola*, with 20 grooves on the last whorl, can be separated from the remaining species by shell color and habitat. We group the remaining six species, with 26-38 grooves on the last whorl, in the *G. indentata* complex (*G. carolinensis* [Cockerell], *G. indentata* [Say], *G. ocoae* Hubricht, *G. praecox* [H.B. Baker], *G. rimula* Hubricht, and *G. umbilicata* [Cockerell]). Three of these species (*G. carolinensis*, *G. indentata*, and *G. praecox*) have been reported from the vicinity of Washington, DC. In addition, any similar-looking undescribed species mentioned by Hubricht (1985) would be in this complex.

Glyphyalinia cf. *luticola* Hubricht, 1966 – (DM, PP). Shells were found in both cat-tail marsh and the surrounding swamp forests and a live animal was found in floodplain swamp along Piscataway Creek on 19 February 2011. This species was separated with difficulty from specimens in the *G. indentata* complex following the recommendations of Hubricht (1966) that shells found in marshes and swamps, with a coppery color and smaller umbilicus are *G. luticola*. The transverse grooves on the four specimens attributable to *G. luticola* were more widely spaced at nearly four whorls, especially near the aperture, than in *G. indentata* from upland sites.

Glyphyalinia cryptomphala (Clapp, 1915) – (FW [BM], TR). One shell was found at each of two sites in the survey area, in deciduous forest and a dry, open site. At maturity, this species is distinguished from *G. indentata* by its closed umbilicus, or a tongue-shaped, calcareous flap over the umbilicus. We follow Turgeon et al. (1998) in treating *Glyphyalinia solida* (H.B. Baker) as a synonym of *G. cryptomphala*.

Glyphyalinia wheatleyi (Bland, 1883) – (FW [SM], GF, PP [SM], TR). This species was regularly found in low numbers in leaf litter on the Coastal Plain and in the Piedmont. It was found alive on 19 September and 17 October 2010. *Nesovitrea electrina* (Gould), a similar species that reaches its southern Coastal Plain limits in northern Virginia but not recorded during this study, differs from *G. wheatleyi* in its smaller size at maturity (to 5.2 mm), preference for wetter habitats, smoother shell nearly lacking radial grooves, and especially by its rounder aperture.

OXYCHILIDAE

Oxychilus draparnaudi (Beck, 1837) – (JP, OC). This introduced European snail was found on a landfill site at the border of the District of Columbia and Prince Georges County (Steury & Steury, 2011). A live animal was found in the City of Alexandria on 8 April 2010 under a concrete slab.

PRISTILOMATIDAE

Hawaiia minuscula (A. Binney, 1841) – (DM swamp, FF, FH, FW [BE, BH, BM, BS, BW, fw], PP [SM, WR swamp]). This species was found only on the Coastal Plain, where it was most common at historic batteries and forts surrounded by turf grass. It was also found in historically similar areas with concrete or mortar that have succeeded to second growth woodland (Battery Emory) or even at sites that are now mature forest (where it was found in leaf litter) such as the rifle butts along the river trail at Fort Washington Park and shell marl ravine forest in Piscataway Park. It was the most common snail found at Fort Hunt Park. Live snails were observed between 17 April and 16 October 2010. Hubricht (1985) described its habitat as bare ground on floodplains, meadows, roadsides, and waste ground in urban areas, noting that he had never found it in leaf litter. However, Baker (1939) described its habitat as woodlands of oak, hickory, and sycamore. Within the study area, seven live snails with shell form and sculpture seemingly identical to *H. minuscula* were found in swamp habitats (under loose bark of a fallen tree in Dyke Marsh swamp on 18 October 2010, with *Vertigo ovata*, and on 5 March 2011, under loose bark in a remote swamp at Accokeek Creek). Both of these populations differed slightly in life (yellowish tan bodies visible through the transparent shell) from *H. minuscula* found in open grassy areas (shells occasionally tinted yellow instead of the more common transparent or opaque white color, but the paler animals give the transparent shells a whiter appearance). A shell

found in a swamp at Wharf Road was likely attributable to river drift. Shells from open grassy areas of juvenile animals up to 3.5 whorls are usually transparent and become opaque white at maturity or with shell aging after death. A more thorough examination of the swamp *Hawaiia* is warranted to determine whether habitat or diet could account for the different body coloration or if it may prove to be a different or new species.

LIMACIDAE

Ambigolimax valentiana (Férussac, 1823) – (Collingwood Picnic Area, JP, RR). Five of these introduced slugs, native to the Iberian Peninsula of Europe and previously placed in the genus *Lehmannia*, were found after dark on the curb of a parking lot near the Potomac River on 11 June 2011. Three days later, a colony of nine slugs was found under moist debris in swamp forest and the next day, one slug was found in similar habitat at Jones Point. This species was previously unrecorded from any county in the survey area.

Limax maximus Linnaeus, 1758 – (DI, FW [SM], GF, JP, TR). This large introduced European slug was uncommon in the survey area. It was typically found in woodlands under logs.

MILACIDAE

Milax gagates (Draparnaud, 1801) – (TR). Eleven of these introduced slugs native to the western Mediterranean and Canary Islands were found along the concrete base of an office building in Turkey Run Park on 19 June 2011.

AGRIOLIMACIDAE

Deroceras laeve (Müller, 1774) – (DM, JP, PP [WR swamp], RI, RR). This native slug occurred only in wetlands (e.g. under logs in a cat-tail marsh [9 September 2010; n = 2]; wet leaf litter in swamps [7 October 2010; n = 2]). It was found on the shore of Jones Point on 3 March 2011, and as early as 19 February, in swamps at Wharf Road.

Deroceras reticulatum (Müller, 1774) – (JP, PH). Thirteen of these introduced European slugs were found on the western shore of Jones Point under woody debris on 3 March 2011 and one was observed at a culvert outfall on the bank of the Potomac River along the Potomac Heritage Trail on 17 June 2011. The population at Jones Point is highly variable in color, ranging from a dark gray to a pale cream background with variable amounts of dark reticulations. When disturbed, this slug secretes a milky mucus diagnostic for the species (McDonnell et al., 2009). This species was previously unrecorded from any county in the study area.

ARIONIDAE

Arion hortensis Férussac, 1819 – (DI). This introduced European slug was found under a log along a wooded bank of the Potomac River. This taxon concept was expanded by Davies (1979) to include three similar species (*A. distinctus* Mabille, *A. hortensis*, and *A. owenii* Davies). Pearce & Bayne (2003) determined the first two of these occur in the eastern United States. The key provided by McDonnell et al. (2009) suggests that the population on Daingerfield Island is *A. hortensis*, having sides below the lateral bands contrasting and pale, no break in right mantle band above the pneumostome, and tentacles that are faintly reddish rather than dark blue-black. Dissection of the larger of our two specimens, although immature, revealed two elongated structures (not fully developed) oriented perpendicular to the epiphallus duct, which is closer to the anatomy of the verge in *A. hortensis* than *A. distinctus*.

Arion intermedius (Normand, 1852) – (FW [SC floodplain], GF). This introduced European slug was found within the survey area at only two sites (one each in the Piedmont and Coastal Plain), including under a rotting log on a slope above Great Falls Swamp on 24 August 2010, and under logs along the bank of Swan Creek on 17 July 2010.

Arion subfuscus (Draparnaud, 1805) – (DI, FW [SM], GF, TR). This introduced European slug was the most commonly observed slug within the survey area, recorded at nearly every wooded site sampled, generally under logs or loose bark.

PHILOMYCIDAE

Megapallifera mutabilis (Hubricht, 1951) – (GF, TR). This uncommon slug was found only in the Piedmont section of the survey area, typically in rotting logs. It was observed between 21 April and 24 August 2010. Two entwined slugs were observed inside a standing rotting tree in Great Falls Swamp on 24 August 2010.

Philomycus carolinianus (Bosc, 1802) – (GF, PP). An uncommon but widespread slug within the survey area, it was observed at only four sites between 21 April and 13 November 2010, and on 5 March 2011, under rotting

logs or loose bark of fallen trees. A population in Johnson's Gulley in Piscataway Park contained melanistic individuals.

POLYGYRIDAE

Mesodon thyroidus (Say, 1816) – (DM, FF, FH, FW [BE, BW, fw, SM, SC floodplain], GF, OC, PH, PP, RI, TR). This snail possesses the second largest shell of any species found within the survey area. It is a common and widespread species found at nearly every site, but is most common in calcareous woodlands such as shell marl forest. This species was commonly observed climbing the trunks of smooth barked trees such as *Asimina triloba* (L.) Dunal and *Carpinus caroliniana* Walter to a height of 2 m in mid-summer but was never observed climbing in the spring. A live animal was found under a log in Dyke Marsh on 9 September 2010. On 17 July 2010, one snail had climbed a *Lindera benzoin* to a height of 1 m and appeared to be feeding on a bird dropping on the middle of a leaf. Nearly all (98%) mature shells possessed a parietal denticle. The largest shell measured 26 mm at its widest diameter.

Neohelix albolabris (Say, 1816) – (GF). This was a very rare snail in the survey area, documented by only three live juveniles and three adult shells found in a forested ravine, under loose bark of a large fallen tree, near the center of Great Falls Park. This is the largest species in the survey area; the largest specimen measured 28 mm at its widest diameter. We believe that the snails from the *N. albolabris* group collected in the Piedmont are *N. albolabris* rather than its Coastal Plain congener *N. solemi* (Emberton, 1988). Örstan (1999) confirmed *N. albolabris* from near this latitude in Montgomery County, Maryland by dissection. Juveniles of *N. albolabris* can be distinguished from those of *M. thyroidus* by having a thinner shell at a similar diameter and thinner lip over the umbilicus without a smooth edge.

Stenotrema barbatum (Clapp, 1904) – (FW [BE, SM], PH, TR). This was an uncommon snail found at only four sites in leaf litter in deciduous woodland. This species was reported for Prince Georges County by Grimm (1971a) but the record was not included by Hubricht (1985). Of ten mature shells found in shell marl forest at Fort Washington Park, 40% lacked the parietal denticle and instead possessed a shiny callous thickening in the parietal area. Shell diameter (8.8 - 9.1 mm) and density of periostrical hairs (<4 per mm) on these shells indicate they are more like *S. barbatum* (> 8 mm; 4 periostrical hairs per mm) than *S. hirsutum* (6 - 8 mm; 5 - 6 periostrical hairs per mm) (Grimm, 1971b; Perez, 2011).

A juvenile shell of 2.3 whorls with appressed pubescence found in moist leaf litter at the base of a southeastern facing slope along Difficult Run in Great Falls Park may be attributable to *S. barbatum* or possibly *S. hirsutum* (Say, 1817). It differed from other juvenile shells of *S. barbatum* of the same size by having appressed pubescence rather than stiffly erect hairs.

Triodopsis juxtidens (Pilsbry, 1894) – (FW [BM, BWh, SM], GF, JP, LH, PH, PP, RI, TR). This is a widespread, but never abundant, species of woodland sites nearly always in or under moist rotting logs. Live snails were found between 2 April and 24 August 2010. Broken shells of this species and *Anguispira alternata* found between stones in the walls of Battery White 1.5 m above the ground may have been placed there by rodents.

Xolotrema denotatum (Férussac, 1821) – (PP [SM]). This typically montane species was found at two sites on the Coastal Plain in shell marl ravine forest in Piscataway Park on 30 April 2011. Nine live juveniles and one juvenile shell were found under loose bark of fallen trees along Accokeek Creek, and one fresh, mature shell and one live juvenile were found in Johnson's Gulley. Juveniles are easily distinguished from other species with periostrical hairs that could occur in the area such as *Stenotrema* or *Euchemotrema* by their larger nuclear whorl and shell diameter. The flora of these calcareous areas also contains a number of species more typically associated with sites in western Maryland and Virginia (Steury & Davis, 2003). These are the southernmost Coastal Plain sites on the East Coast.

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LITERATURE CITED

Armbruster G. 1995. Univariate and multivariate analyses of shell variables within the genus *Cochlicopa* (Gastropoda: Pulmonata: Cochlicopidae). Journal of Molluscan Studies 61: 225-235.

Armbruster G., & M. Schlegel. 1994. The land-snail species of *Cochlicopa* (Gastropoda: Pulmonata: Cochlicopidae): presentation of taxon-specific allozyme patterns and evidence for a higher level of self-fertilization. Journal of Zoological Systematics and Evolutionary Research 32: 282-296.

Arnaud, J. F., L. Madec, A. Bellido, & A. Guiller. 1999. Microspatial genetic structure in the land snail *Helix aspersa* (Gastropoda: Helicidae). Heredity 83: 110-119.

Baker, F. C. 1939. Fieldbook of Illinois Land Snails, Manual 2. State of Illinois Natural History Survey Division. Urbana, IL. 166 pp.

Beetle, D. E. 1973. A checklist of the land and freshwater mollusks of Virginia. Sterkiana 49: 21-35.

Brooks, F. J. 1999. Stratigraphy and landsnail faunas of late Holocene coastal dunes, Tokerau Beach, northern New Zealand. Journal of the Royal Society of New Zealand 29: 337-359.

Bouchet, P., & J. P. Rocroi. 2005. Classification and nomenclator of gastropod families. Malacologia 47: 1-397.

Burch, J. B. 1962. How to Know the Eastern Land Snails. Wm. C. Brown Company, Dubuque, IA. 214 pp.

Davies, S. M. 1979. Segregates of the *Arion hortensis* complex (Pulmonata: Arionidae) with the description of a new species, *Arion owenii*. Journal of Conchology 30: 123-128.

DeWitt, W. B. 1952. *Pomatiopsis lapidaria*, its occurrence in the Washington, D.C. area and its laboratory rearing in comparison to that of *Oncomelania* spp. Journal of Parasitology 38: 321-326.

Dundee, D. S. 1974. Catalog of introduced mollusks of eastern North America (north of Mexico). Sterkiana 55: 1-37.

Emberton, K. C. 1988. The genitalic, allozymic, and conchological evolution of the eastern North American Triodopsinae (Gastropoda: Pulmonata: Polygyridae). Malacologia 28: 159-273.

Grimm, F. W. 1960. Two new succineids from Maryland, with notes on *Catinella vermeta*. Nautilus 74: 8-15.

Grimm, F. W. 1971a. Annotated checklist of the land snails of Maryland and the District of Columbia. Sterkiana 41:51-57.

Grimm, F. W. 1971b. Two new *Stenotrema,* with notes on *S. hirsutum* and *S. barbatum.* Nautilus 85: 12–17.

Grimm, F. W. 1981. A review of the Chittenango ovate amber snail, *Succinea chittenangoensis*, Pilsbry, 1908 – a Pleistocene relict now greatly restricted in distribution. Contract report to the New York State Department of Environmental Conservation Endangered Species Unit. 30 pp.

Hoagland, K. E., & G. M. Davis. 1987. The succineid snail fauna of Chittenango Falls, New York: taxonomic status with comparisons to other relevant taxa. Proceedings of the Academy of Natural Sciences of Philadelphia 139: 465-526.

Horsák, M., J. Šteffek, T. Čejka, V. Ložek, & L. Juřičková. 2009. Occurrence of *Lucilla scintilla* (R.T. Lowe, 1852) and *Lucilla singleyana* (Pilsbry, 1890) in the Czech and Slovak Republics – with remarks how to distinguish these two non-native minute snails. Malacologica Bohemoslovaca 8: 24–27.

Hotopp, K. P. 2002. Land snails and soil calcium in Central Appalachian mountain forest. Southeastern Naturalist 1: 27-44.

Hubricht, L. 1951. Three new land snails from the eastern United States. Nautilus 65: 57-59.

Hubricht, L. 1966. Four new land snails. Nautilus 80: 53-56.

Hubricht, L. 1974. A review of some land snails of the eastern United States. Malacolgical Review. 7: 33-34.

Hubricht, L. 1985. The distribution of native land mollusks of the eastern United States. Fieldiana, Zoology New Series No. 24. 191 pp.

Lydeard, C., R. H. Cowie, W. F. Ponder, A. E. Bogan, P. Bouchet, S. A. Clark, K. S. Cummings, T. J. Frest, O. Gargominy, D. G. Herbert, R. Hershler, K. E. Perez,

B. Roth, M. Seddon, E. E. Strong, & F. G. Thompson. 2004. The global decline of nonmarine mollusks. BioScience 54: 321-330.

McDonnell, R. J., T. D. Paine, & M. J. Gormally. 2009. Slugs, a guide to the invasive and native fauna of California. University of California, Division of Agriculture and Natural Resources, Publication 8336.

Morrison, J. P. 1935. Three new land shells from the southern United States. Journal of the Washington Academy of Sciences 25: 545-547.

Naggs, F., S. Panha, & D. Raheem. 2006. Developing land snail expertise in South and Southeastern Asia, a new Darwin Initiative Project. Natural History Journal of Chulalongkorn University 6: 43-46.

Nekola, J. C., & B. F. Coles. 2010. Pupillid land snails of eastern North America. American Malacological Bulletin 28: 29-57.

Niver, R. 2010. Chittenango ovate amber snail (*Novisuccinea chittenangoensis*) spotlight species action plan. U.S. Fish and Wildlife Service, Northeast Region, New York Field Office, Cortland, NY. Accessed on-line at http://www.fws.gov/northeast/ endangered/ PDF/amber_snail.pdf

Norden, A. W. 2007. Life history and ecology of the land snail *Gastrocopta corticaria* (Say) at Plummers Island, Montgomery County, Maryland. Maryland Naturalist 48: 52-55.

Norden, A. W. 2008a. The terrestrial gastropods (Mollusca: Gastropoda) of Plummers Island, Maryland. Pp. 31-40 *In* J.W. Brown (ed.), The invertebrate fauna of Plummers Island, Maryland, Contribution XXX to the Natural History of Plummers Island, Maryland. Bulletin of the Biological Society of Washington 15.

Norden, A. W. 2008b. Land snails. Pp. 28-29 *In* A. V. Evans (ed.), The 2006 Potomac Gorge Bioblitz, overview and results of a 30-hour rapid biological survey. Banisteria 32.

Örstan, A. 1999. Land snails of Black Hill Regional Park, Montgomery County, Maryland.
Maryland Naturalist 43: 20-24.

Örstan, A. 2010. Reproductive biology and annual population cycle of *Oxyloma retusum* (Pulmonata: Succineidae). American Malacological Bulletin 28: 113-120.

Örstan, A., & T. A. Pearce. 2011. Longevities of colonies of *Pomatiopsis lapidaria*. Tentacle 19: 33-34.

Pearce, T. A. 2008a. Land snails of limestone communities and update of land snail distributions in Pennsylvania. Unpublished report for Pennsylvania's Wild Resource Conservation Program, grant number WRCP-04016.

Pearce, T. A. 2008b. When a snail dies in the forest, how long will the shell persist? Effect of dissolution and micro-bioerosion. American Malacological Bulletin 26: 111-117.

Pearce, T. A., & E. G. Bayne. 2003. *Arion hortensis* Férussac, 1819, species complex in Delaware and Pennsylvania, eastern USA (Gastropoda: Arionidae). Veliger 46: 362-363.

Pearce, T. A., M. C. Fields, & K. Kurita. 2007. Discriminating shells of *Gastrocopta pentodon* (Say, 1822) and *G. tappaniana* (C.B. Adams, 1842) (Gastropoda: Pulmonata) with an example from the Delmarva Peninsula, eastern USA. Nautilus 121: 66-75.

Perez, K. E. 2011. Species key to the terrestrial gastropods of Wisconsin and nearby states. University of Wisconsin – La Crosse. Accessed on-line 6 September 2011 at http://www.uwlax.edu/biology/ faculty/perez/Perez/PerezLab/Research/SpeciesKey. htm#Stenotrema

Perez, K. E., & J. Cordeiro (ed.). 2008. A guide for terrestrial gastropod identification. American Malacological Society Terrestrial Gastropod Identification Workshop. Carbondale, IL. 72 pp.

Pilsbry, H. A. 1948. Land Mollusca of North America north of Mexico. Monograph 3 of Academy of Natural Sciences of Philadelphia vol. II part 2: 521-1113.

Price, G. J., & G. E. Webb. 2006. Late Pleistocene sedimentology, taphonomy, and megafauna extinction on the Darling Downs, southeastern Queensland. Australian Journal of Earth Sciences 53: 947-970.

Richards, H. C. 1934. A list of mollusks of the District of Columbia and vicinity. American Midland Naturalist 15: 85-88.

Robinson, D. G., & J. Slapcinsky. 2005. Recent introductions of alien land snails into North America. American Malacological Bulletin 20: 89-93.

Roble, S. M. 2013. Natural heritage resources of Virginia: Rare animal species. Natural Heritage Technical Report 13-05. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 46 pp.

Roth, B. 2003. *Cochlicopa* Férussac, 1821, not *Cionella* Jeffreys, 1829; Cionellidae Clessin, 1879, not Cochlicopidae Pilsbry, 1900 (Gastropoda: Pulmonata: Stylommatophora). Veliger 46: 183-185.

Sinclair, C. S. 2010. Surfing snails: Population genetics of the land snail *Ventridens ligera* (Stylommatophora: Zonitidae) in the Potomac Gorge. American Malacological Bulletin 28: 105-112.

Solem, A. 1984. A world model of land snail diversity and abundance. Pp. 6-22 *In* A. Solem & A. C. van Bruggen (eds.) World-wide Snails: Biogeographical Studies on Non-marine Mollusca. Leiden, The Netherlands.

Steury, B. W. 2011. Additions to the vascular flora of the George Washington Memorial Parkway, Virginia, Maryland, and the District of Columbia. Banisteria 37: 3-20.

Steury, B. W. & C. A. Davis. 2003. The vascular flora of Piscataway and Fort Washington National Parks, Prince Georges and Charles counties, Maryland. Castanea 68: 271-299.

Steury, B. W., G. P Fleming, & M. T. Strong. 2008. An emendation of the vascular flora of Great Falls Park, Fairfax County, Virginia. Castanea 73: 123-149.

Steury, B. W., & I. W. Steury. 2011. First records for *Discus rotundatus* and a feral population of *Oxychilus draparnaudi* (Gastropoda) from Washington, DC. Southeastern Naturalist 10: 193-195.

Turgeon, D. D., J. F. Quinn, Jr., A. E. Bogan, E. V. Coan, F. G. Hochberg, & W. G. Lyons. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks, 2nd ed. American Fisheries Society Special Publication 26. American Fisheries Society, Bethesda, MD. 526 pp.

Vanatta, E. G., & H. A. Pilsbry. 1906. On *Bifidaria pentodon* and its allies. Nautilus 19: 121-128.

Wada, S., K. Kawakami & S. Chiba. 2011. Snails can survive passage through a bird's digestive system. Journal of Biogeography 39: 69-73.

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Comparisons of Ectomycorrhizal Fungi and Fine Roots of *Pinus virginiana* Hosts from Two Soil Sources at the Grassy Hill Natural Area Preserve, Franklin County, Virginia

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ABSTRACT

Roots of Virginia Pine (*Pinus virginiana* Mill.) trees from soils of Basic Oak-Hickory Forest (BOHF) and Mountain/Piedmont Acidic Woodland (MPAW) ecological communities at the Grassy Hill Natural Area Preserve (Franklin County, Virginia) differing in soil pH and moisture were compared for ectomycorrhizal (ECM) fungal properties and fine root length. ECM colonization, community composition, morphotype/species richness, and fine root length were assessed from eight BOHF and nine MPAW trees. While soil cores from these trees represented a relatively low sample size, colonization was found to not differ, but ECM fungal composition varied as richness and the respective numbers of dominant and less abundant morphotypes differed from each soil source. Total richness was greater, and mean richness per meter fine root was significantly greater in the more acidic xeric MPAW soil, while fine root length was significantly greater in the less acidic sub-mesic BOHF soil. Our results are the first to characterize ECM properties and fine root growth from *P. virginiana* trees growing in these two soil sources.

Key words: ectomycorrhizae, fine roots, Grassy Hill, pH, *Pinus virginiana*, soil moisture.

INTRODUCTION

Ectomycorrhizal (ECM) fungi are key components of temperate forests, benefiting hosts by facilitating their nutrient and water uptake, and increasing their tolerance of stressful soil conditions (Smith & Read, 2008). Many trees in Virginia's Blue Ridge Mountains, including Virginia Pine (*Pinus virginiana* Mill.), Sourwood (*Oxydendrum arboreum* [L.] DC.), and Chestnut Oak (*Quercus prinus* L.), grow in acidic and xeric soils (Virginia Department of Conservation and Recreation, 2012), partly due to ECM facilitation (McQuilkin, 1990). This is not surprising, given that both conventional morphotyping and more contemporary DNA-based methods have found that ECM fungi tolerate a range of soil conditions, including moisture levels and pH values (Slankis, 1974; Gehring et al., 1998; Peter et al., 2001; Jany et al., 2003; Abler, 2004; Buée et al., 2005). To better understand the influence of variable soils on ECM fungi and their hosts, we compared ECM fungal and fine root properties of *P. virginiana* trees growing in Basic Oak-Hickory Forests (BOHF) and Mountain/Piedmont Acidic Woodlands (MPAW) communities, whose soils differ in moisture levels and pH.

MPAW communities are rare in the southeastern U.S., but occur in Virginia mountains as barrens characterized by shallow, highly xeric soils. In contrast, BOHF communities are more common across the state, and have deeper, more mesic soils (Virginia Department of Conservation and Recreation, 2012). Both are coniferous or coniferous-deciduous, often being dominated by *Pinus* and *Quercus* species that associate with numerous ECM fungal taxa, many of

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which tolerate acidic soils (Brundrett, 2003). In fact, most ECM fungi grow well between pH values of 4.5 and 5.5 (which include the values of our soils), while others do so under lower values (McAfee & Fortin, 1987; Lehto, 1994).

Ultimately, the success of temperate trees growing in acidic soils depends on ECM fungi. Tree growth and survival are positively correlated with ECM colonization in acidic soils (Erland & Söderström, 1990), due to increased nutrient access. In addition, ECM fungi increase host water access in xeric soils (Gehring & Whitham, 1994). Although studies have examined ECM communities in soils defined by a range of moisture levels and pH values as single variables, fewer have done so in soils with two variables, and none to our knowledge has examined ECM communities on *P. virginiana* hosts in BOHF and MPAW communities. In this study, we examined *in situ* ECM properties and root growth on *P. virginiana* trees growing in these two community types at the Grassy Hill Natural Area Preserve in Franklin County, Virginia. We predicted that there would be differences in ECM colonization, community composition, and diversity between BOHF and MPAW soils based on studies finding differences in these variables in similarly contrasting soils (Gehring & Whitham, 1994; Gehring et al., 1998). However, given the lack of studies reporting differences in fine root length from ECM hosts from similarly contrasting soil types, no prediction was made regarding fine root length.

MATERIALS AND METHODS

Study Sites and Host Species

We conducted our study at the Grassy Hill Natural Area Preserve, located at the northwest edge of Rocky Mount, Virginia (36° 59′ 60″ N, 79° 53′ 23″ W). The Virginia Department of Conservation and Recreation's Division of Natural Heritage manages the Preserve to conserve biodiversity and ecological communities. It lies in the Piedmont physiographic province (Roberts & Bailey, 2000) and southern oak/pine forest zone (Yahner, 2000). It is composed primarily of *Carya* and *Quercus* stands, interspersed with *P. virginiana*, that are fairly undisturbed except for a few roads and power lines (Turner & Demkó, 2007). The terrain is described by magnesium-rich bedrock overlain with heavy clay soils (Virginia Department of Conservation and Recreation, 2013), with rocky slopes reaching 535 m ASL (United States Geological Survey and Virginia Division of Mineral Resources, 1985). Average monthly precipitation ranges from 7.7 to 12.8 cm and temperatures range from –3.4 to 30.2 C (National Weather Service, 2011; values derived from data collected at the Rocky Mount station from 1981 to 2010).

Basic Oak-Hickory Forests (BOHF) and Mountain/Piedmont Acidic Woodlands (MPAW) communities were compared because their soil moisture levels and pH differ (Table 1; M. Leahy, unpubl. data). Although tree composition was similar in each community, there were differences: *Quercus*, *Carya*, and *Acer* species were the dominant trees in the BOHF, whereas *Oxydendrum arboreum*, *Pinus*, and *Quercus* species were dominant in the MPAW communities. *Pinus virginiana* served as our host species because it associates with many ECM fungal taxa (e.g., *Cenococcum*, *Russula*, and *Tomentella*; Hepting, 1971; Abler, 2004) and is found in both communities. The species has shallow roots, grows well in xeric to sub-mesic soils (Carter & Snow, 1990) and tolerates pH values of 4.2 to 7.9 (Miller & Cumming, 2000) – values in which ECM fungi enable its survival (Thiet & Boerner, 2007). Thus ECM fungi were expected to associate with this host in both soil sources.

Field Sampling

In May 2006, we identified *P. virginiana* trees in each of three BOHF and MPAW plots designated within sites previously surveyed for abiotic and vegetative profiles (M. Leahy, unpubl. data). Only two sites of each community were used because only two BOHF sites had a sufficient number of trees to sample. Plots were located more than 500 m apart, and in each, three *P. virginiana* trees with DBH >10 cm were randomly selected, except in one BOHF site where only two suitable host trees occurred. Trees were farther than 5 m from one another, given that ECM fungi less than 3 m apart may be from the same mycelium (Turner et al., 2009). Root extractions were timed to coincide with spring ECM flush (Walker et al., 2008). Blocks of 500 cm^3 (i.e., soil blocks 5 x 10 x 10 cm deep) were cut and extracted 1-3 m from each tree base (i.e., 2 plots × 3 trees × 3 blocks + 1 plot × 2 trees × 3 blocks = 24 BOHF blocks; 3 plots × 3 trees × 3 blocks = 27 MPAW

Table 1. Soil properties from Basic Oak-Hickory Forest (BOHF) and Mountain/Piedmont Acidic Woodland (MPAW) communities.

	Ecological Community	
	BOHF	MPAW
Soil pH range	4.9-5.0	4.3-4.5
Mean % organic matter	4.2	4.3
Soil moisture regime	Sub-mesic	Xeric
Mean soil depth (cm)	7.8	6.6

blocks) by use of a soil spade immersion-sterilized in a 9:1 mixture of bleach and water, followed by rinsing before each extraction. Blocks were then wrapped in new aluminum foil and taken to Ferrum College for analysis.

Fungal Morphotyping, Quantification, and Statistics

We exposed roots in each sample block by soaking and gently rinsing them with tap water over sieves to remove adhered pebbles, soil, and dead organic matter. Any remaining pebbles or organic matter was then removed from each sample manually, using tweezers and root snips. We randomly selected a subsample of all of the cleaned fine roots (i.e., any root <1 mm in diameter), representing approximately 50% of all fine roots per sample. Species were identified, and morphotypes were described, using macroscopic morphotyping methods (i.e., Ingleby et al., 1990) based upon root tip branching pattern and shape, mantle color and texture, and presence and abundance of hyphae and rhizomorphs (Table 2, Fig. 1), using an Olympus SZ61 stereoscope. All but one type was not identifiable to species using these procedures, and so were named based on the order in which they were described and on their predominant color. Colonization was expressed as the total numbers of colonized tips per meter fine root. Tips at least partially covered by fungal tissue were considered colonized. We characterized community composition by determining the percent contribution of each morphotype/species. Our assessments of ECM diversity relied upon morphotype richness and evenness. Richness was measured as the number of ECM types per meter fine root length, while evenness was determined by comparing the ranked proportional contributions of each morphotype per soil source. We quantified fine root length using Tennant's (1975) root intercept method for all fine roots.

Our study was intended to test for differences in ECM and host properties between BOHF and MPAW soils. However, our design was limited by a lack of resources, thus we examined the cumulative effects of BOHF and MPAW soil parameters on these properties. In addition, given the variability in the number of fine roots, the amount of dead organic matter, and the number of viable ECM roots tips found in each root sample block, blocks from each tree were consolidated to yield a total of nine MPAW and eight BOHF samples to analyze. After performing tests for normality (i.e., histograms, skewness and kurtosis, and homogeneity of variance), we analyzed colonization data with t-tests, while richness and fine root length were analyzed with

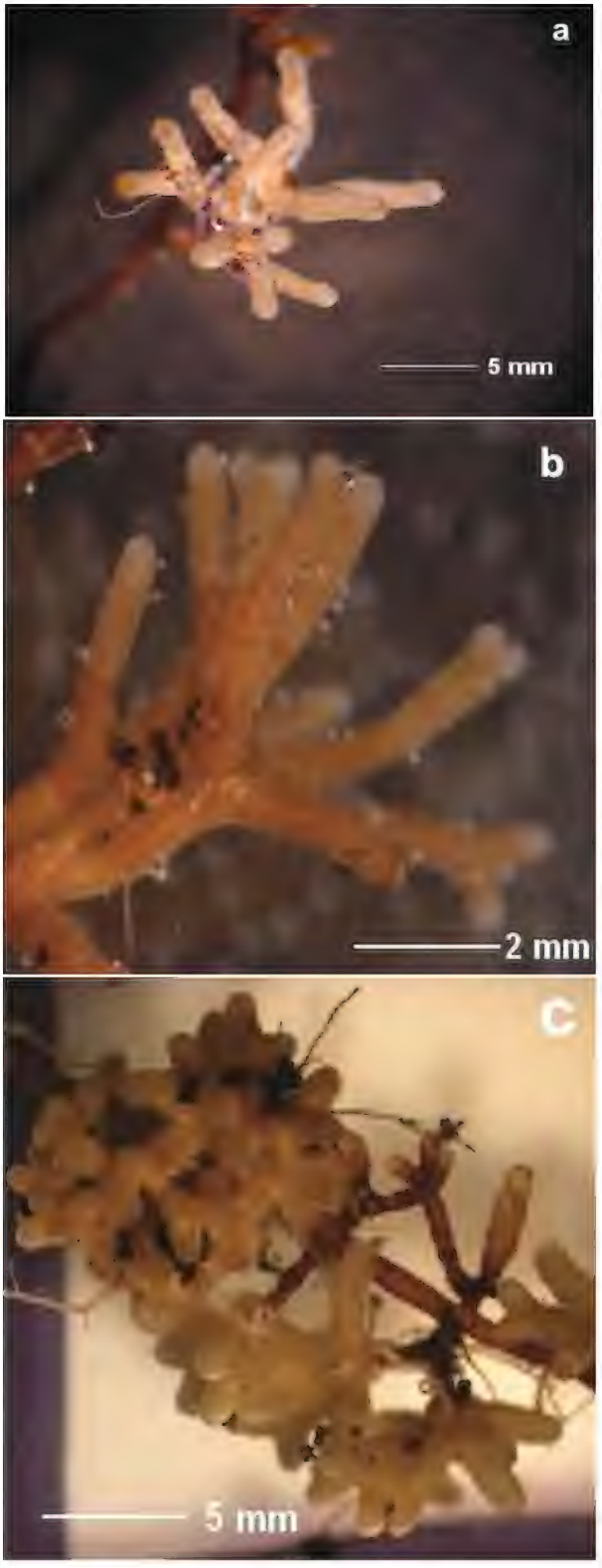

Fig. 1. (a) Irregularly pinnate copper morphotype, (b) dichotomous rust morphotype, and (c) irregularly coralloid white morphotype intermingled with charcoal black *Cenococcum geophilum*.

Table 2. Descriptions and proportional percentage colonization of ectomycorrhizal (ECM) fungal morphotypes in relation to all root tips colonized by all types pooled in Basic Oak-Hickory Forests (BOHF) and Mountain/Piedmont Acidic Woodlands (MPAW) soils.

ECM type	Branching pattern; tip shape; mantle color and texture; presence and abundance of hyphae; presence of rhizomorphs.	% Colonization	
		BOHF	MPAW
Cenococcum geophilum	Unbranched; straight; charcoal black, grainy; common; not present	24.2	31.6
E1br	Unbranched; straight; brown, grainy; not present; not present		0.5
E2co	Irregularly pinnate; slightly bent; copper, grainy; sparse; sparse		0.1
E3cr	Monopodial pinnate; slightly bent; cream, grainy; not present; not present		0.1
E4og *Tomentella*-like	Monopodial pyramidal; straight to slightly bent; olive green, grainy to smooth; rare; not present	1.3	
E5rw	Irregularly pinnate; slightly bent; reddish white, smooth; not present; not present		16.3
E6ru	Dichotomous; slightly bent; rust, smooth; not present; not present	1.5	5.7
E7si *Boletus*-like	Irregularly pinnate; straight to slightly bent; silver, felty; common; not present	0.4	1.2
E8w	Irregularly coralloid; straight; white, smooth; not present; not present	61.8	31.3
E9y	Irregular; bent; yellow tan, smooth; not present; not present	10.8	13.2

Mann-Whitney U tests (SPSS version 16.0, Chicago, IL). Differences in the percentage of root tips colonized by morphotypes between soil sources were analyzed with G-tests. We used Mann-Whitney and G-tests because the data for each violated the assumptions of t-tests and Chi-squared tests, respectively. Differences for all tests were considered significant if $P < 0.05$.

RESULTS

ECM colonization did not differ between *P. virginiana* roots from the two communities ($F = 1.101$, $P = 0.415$). Mean colonized root tips per meter fine root were 67.7 ± 8.8 (SE) and 80.9 ± 12.5 in BOHF and MPAW soils, respectively. Nine distinct morphotypes and the ubiquitous Ascomycete *Cenococcum geophilum* Fr. were described or identified in both soil sources (Table 2). One and four types were exclusive to BOHF and MPAW soils, respectively, whereas five occurred in both soils. E8w and *C. geophilum* were abundant in both soils, representing 62 and 24% of colonized tips, respectively, in BOHF soils, and approximately 1/3 each in MPAW soils. E9y was relatively abundant in BOHF soils, as were E5rw and E9y in MPAW soils. Collectively, E8w, *C. geophilum*, and E9y accounted for ca. 97% of colonization in BOHF soils, while *C. geophilum*, E8w, E5rw, and E9y accounted for ca. 92% in MPAW soils. Two infrequent types, E6ru and E4og, and the rare type E7si accounted for just over 3% of colonization in BOHF soils, while two infrequent types, E6ru and E7si, and rare types E1br, E2co, and E3cr accounted for 7.6% in MPAW soils. Overall, ECM community composition differed between soil sources; BOHF soils were dominated by one type and had less diversity whereas MPAW soils had no dominant type and higher diversity. Furthermore, while all but E8w was more abundant in MPAW soils, G-tests found that E6ru and E7si were significantly more abundant in MPAW than BOHF soils. *Cenococcum geophilum*, E8w, and E9y did not differ between soils.

Mean morphotype richness was significantly different ($U = 7.595$, $P = 0.007$), being three times greater per meter fine root in MPAW as compared to BOHF soils (i.e., 0.57 ± 0.13 versus 0.19 ± 0.05), while evenness was qualitatively similar in MPAW and BOHF soils (i.e., fewer dominant types and more spread; Fig. 2). Similarly, host fine root length was significantly different ($U = 13.000$, $P = 0.027$), being more than twice as long in BOHF than MPAW soils (28.8 ± 4.55 vs. 10.7 ± 1.6 cm).

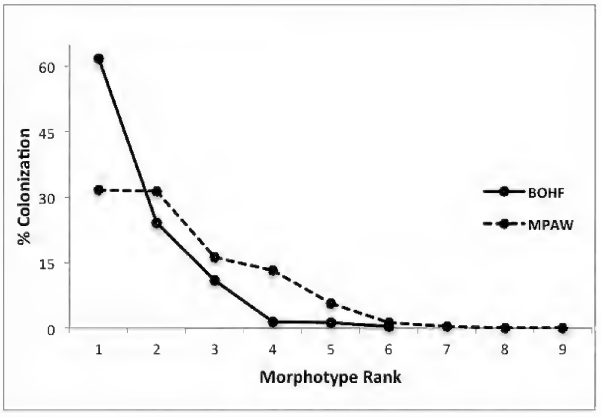

Fig. 2. Rank abundance patterns for ECM morphotypes from *Pinus virginiana* host trees growing in Basic Oak-Hickory Forests (BOHF) and Mountain/Piedmont Acidic Woodlands (MPAW) soils.

DISCUSSION

ECM colonization did not differ between soil sources, which is not surprising given that other relevant studies report similar findings. For example, Edwards & Kelly (1992) found no colonization differences on Loblolly Pine (*P. taeda* L.) from soils with pH values of 3.8 and 5.2, though they assessed seedlings, rather than trees, exposed to ozone and magnesium in open air chambers. A study of Pinyon Pine (*P. edulis* Engelm.) from xeric and less xeric soils in an Arizona forest found that there were no differences in colonization (Gehring et al., 1998), and, like our results, that only one or a few morphotypes dominated ECM composition. However, it is important to note that we had more limited sampling, our types were based on conventional morphotyping, and that most current analogous studies use DNA identification methods (e.g., PCR analyses and sequencing), often finding greater sample species richness and more complex composition from various hosts and systems (Dahlberg, 2001; Jany et al., 2003; Tedersoo et al., 2003; Smith & Read, 2008).

Regardless, we found that composition varied, given that total richness and the numbers of dominant and rare types differed between soil sources. Differences in colonization shown by individual types may reflect responses to factors unique to each soil. For example, three types (i.e., E6ru, E7si, and E9y) were more abundant in MPAW soils (E6ru and E7si significantly so), suggesting that these types may be more acid-tolerant than others, as Erland & Söderström (1990) and Lehto (1994) found for *Pisolithus* and *Suillus* species associated with *Abies* and *Picea* hosts. We also found that *C. geophilum* and E9w colonization were similar in both soils, suggesting that these fungi tolerate a wide range of pH values, as Rao et al. (1997) observed for *P. kesiya*-associated *C. geophilum* in soils with variable pH values. However, while colonization by some morphotypes in our study may at least partly reflect responses to pH, these same types, and others, may also have responded to differences in soil moisture, as Gehring et al. (1998) observed. E5rw and E8w, for example, may have affinities for xeric and sub-mesic soils, respectively. By contrast, *C. geophilum*, with roughly equal abundances in both soil sources, likely tolerates a greater range of moisture levels, as Worley & Hacskaylo (1959) observed for it colonizing *P. virginiana* seedlings grown in Maryland forest soils in the greenhouse.

Richness differed significantly between soil sources, with three times more ECM morphotypes per meter fine root in MPAW than BOHF soils. Greater MPAW richness may reflect the ability of more types to tolerate lower pH and xeric soils, as Gehring & Whitham (1994) found for *P. edulis* types, and some types that may be acidophilic (e.g., E1br and E5rw). Another factor that may have influenced differences in richness is fine root length, with which it has been positively correlated on *Picea* and *Quercus* hosts (Korkama et al., 2006; Turner et al., 2009). However, our results differ from these patterns, because we found that fine root length was significantly lower in the more morphotype-rich MPAW soils. In addition, ECM fungi were less evenly structured in BOHF than MPAW soils (Fig. 2) as evidenced by the steeper slope representing the BOHF community (i.e., 62% proportional colonization by E8w), and the occurrence of fewer dominant and more rare types in MPAW soils. Considering evenness with richness, our results suggest that ECM communities may be more diverse on *P. virginiana* hosts from MPAW than BOHF soils.

Fine root length was significantly greater in BOHF than MPAW soils. Organic matter and soil depth did not differ greatly between soils (Table 1). Although these factors can affect root growth (Gehring et al., 1998; Hertel et al., 2003), it is unlikely they did so in our study. Soil pH also affects root growth, though no clear patterns have emerged from the literature. For example, Lehto (1994) reports negative effects while Brunner et al. (2002) found weak or no effects. In contrast, soil moisture may have been influential because it is known to be positively correlated with fine root growth (López et al., 1998; Wilcox et al., 2004; Olesinski et al., 2011). *Pinus virginiana* may operate similarly, growing longer fine roots in the moister BOHF than the xeric MPAW soils.

In summary, ECM composition and richness on *P. virginiana* hosts differed between BOHF and MPAW soils at the Grassy Hill Natural Area Preserve.

Morphotype richness was greater in MPAW soils and, like composition, may have been affected by differences in the response of individual morphotypes to moisture levels and pH. Greater *P. virginiana* fine root length in BOHF soils likely reflects the host's ability to grow longer fine roots in moister soils. Our findings corroborate some studies reporting differences in ECM fungi in response to variable soil moisture levels or pH, respectively. However, as stated earlier, our explanations were based on cumulative plot-level differences in key soil parameters and relied on small, consolidated samples. Thus, more research, including bioassays, outplantings, and local-scale soil parameter manipulations would go far in helping us to better understand how ECM fungi and fine roots respond to differences in key soil parameters. In addition, future studies might also consider that factors like soil moisture and pH, root length, and vegetative composition may be covariates for ECM colonization.

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LITERATURE CITED

Abler, R. A. B. 2004. Trace metal effects on ectomycorrhizal growth, diversity, and colonization of host seedlings. Ph. D. dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA. 161 pp.

Brundrett, M. C. 2003. Coevolution of roots and mycorrhizas of land plants. New Phytologist 154: 275-304.

Brunner, I., S. Brodbeck, & L. Walthert. 2002. Fine root chemistry, starch concentration, and 'vitality' of subalpine conifer forests in relation to soil pH. Forest Ecology and Management 165: 75-84.

Buée, M., D. Vairelles, & J. Garbaye. 2005. Year-round monitoring of diversity and potential metabolic activity of the ectomycorrhizal community in a beech (*Fagus silvatica*) forest subjected to two thinning regimes. Mycorrhiza 15: 235-245.

Carter, K. K., & A. G. Snow, Jr. 1990. *Pinus virginiana* Mill. Virginia pine. Pp. 513-519 *In* R. M. Burns & B. H. Honkala (tech. coordinators), Silvics of North America. Volume 1. Conifers. Agricultural Handbook 654. United States Department of Agriculture, Forest Service, Washington, DC.

Dahlberg, A. 2001. Community ecology of ectomycorrhizal fungi: an advancing interdisciplinary field. New Phytologist 150: 555-562.

Edwards, G. S., & J. M. Kelly. 1992. Ectomycorrhizal colonisation of loblolly pine seedlings during three growing seasons in response to ozone, acidic precipitation and soil Mg status. Environmental Pollution 76: 71-77.

Erland, S., & B. Söderström. 1990. Effects of liming on ectomycorrhizal infecting *Pinus sylvestris* L.: I. Mycorrhizal infection in limed humus in the laboratory and isolation of fungi from mycorrhizal roots. New Phytologist 115: 675-682.

Gehring, C. A., T. C. Theimer, T. G. Whitham, & P. Keim. 1998. Ectomycorrhizal fungal community structure of pinyon pines growing in two environmental extremes. Ecology 79: 1562-1572.

Gehring, C. A., & T. G. Whitham. 1994. Comparisons of ectomycorrhizae on pinyon pines (*Pinus edulis*; Pinaceae) across extremes of soil type and herbivory. American Journal of Botany 81: 1509-1516.

Hepting, G. H. 1971. Diseases of forest and shade trees of the United States. United States Department of Agriculture, Agriculture Handbook 386. Washington, DC. 658 pp.

Hertel, D., C. Leuschner, & D. Hölscher. 2003. Size and structure of fine root systems in old-growth and secondary tropical montane forests (Costa Rica). Biotropica 35: 143-153.

Ingleby, K., P. A. Mason, F. T. Last, & L. V. Fleming. 1990. Identification of ectomycorrhizas. Institute of Terrestrial Ecology, Natural Environment Research Council, HMSO, Research Publication 5. London.

Jany, J. L., F. Martin, and J. Garbaye. 2003. Respiration activity of ectomycorrhizas from *Cenococcum geophilum* and *Lactarius* sp. in relation to soil water potential in five beech forests. Plant and Soil 255: 487-494.

Korkama T., A. Pakkanen, & T. Pennanen. 2006. Ectomycorrhizal community structure varies among Norway spruce (*Picea abies*) clones. New Phytologist 171: 815-824.

Lehto, T. 1994. Effects of soil pH and calcium on mycorrhizas of *Picea abies*. Plant and Soil 163: 69-75.

López, B., S. Sabaté, & C. Gracia. 1998. Fine root dynamics in a Mediterranean forest: effects of drought and stem density. Tree Physiology 18: 601-606.

McAfee, B. J., & J. A. Fortin. 1987. The influence of pH on the competitive interactions of ectomycorrhizal mycobionts under field conditions. Canadian Journal of Forest Research 17: 859-864.

McQuilkin, R. A. 1990. *Quercus prinus* L. Chestnut oak. Pp. 1389-1400 *In* R. M. Burns & B. H. Honkala (tech. coordinators), Silvics of North America. Volume 2. Hardwoods. Agricultural Handbook 654. United States Department of Agriculture, Forest Service, Washington, DC.

Miller, S. P., & J. R. Cumming. 2000. Effects of serpentine soil factors on Virginia pine (*Pinus virginiana*) seedlings. Tree Physiology 20: 1129-1135.

National Weather Service Forecast Office. 2011. NOWData – NOAA Online Weather Data for Rocky Mount, Virginia. http://www.nws.noaa.gov/climate/xmacis.php?wfo=rnk. (Accessed 1 March 2013).

Olesinski, J., M. B. Lavigne, M. J. Krasowski, & M. Ryan. 2011. Effects of soil moisture manipulations on fine root dynamics in a mature balsam fir (*Abies balsamea* L. Mill.) forest. Tree Physiology 31: 339-348.

Peter, M., F. Ayer, & S. Egli. 2001. Nitrogen addition in a Norway spruce stand altered macromycete sporocarp production and below-ground ectomycorrhizal species composition. New Phytologist 149: 311-325.

Rao, C. S., G. D. Sharma, & A. K. Shukla. 1997. Distribution of ectomycorrhizal fungi in pure stands of different age groups of *Pinus kesiya*. Canadian Journal of Microbiology 43: 85-91.

Roberts, C., & C. M. Bailey. 2000. Physiographic map of Virginia counties. Virginia Division of Mineral Resources and the United States Geological Survey of Mineral Producing Localities, Charlottesville, VA. http://web.wm.edu/geology/virginia/provinces/pdf/va_counties_phys.pdf. (Accessed 1 March 2013).

Slankis, V. 1974. Soil factors influencing formation of mycorrhizae. Annual Review of Phytopathology 12: 437-457.

Smith, S. E., & D. J. Read. 2008. Mycorrhizal Symbiosis. Academic Press, New York, NY. 800 pp.

Tedersoo, L., U. Kõljalg, N. Hallenberg, and K-H. Larsson. 2003. Fine scale distribution of ectomycorrhizal fungi and roots across substrate layers including coarse woody debris in a mixed forest. New Phytologist 159: 153-165.

Tennant, D. 1975. A test of modified line intersect method of estimating root length. Journal of Ecology 63: 995-1001.

Thiet, R. K., & R. E. J. Boerner. 2007. Spatial patterns of ectomycorrhizal fungal inoculum in arbuscular mycorrhizal barrens communities: implications for controlling invasion by *Pinus virginiana*. Mycorrhiza 17: 507-517.

Turner, G. D., & M. Demkó. 2007. Exotic plant distributions along disturbance corridors at the Grassy Hill Natural Area, Franklin County, Virginia. Banisteria 30: 19-26.

Turner, G. D., J. D. Lewis, J. T. Mates-Muchin, W. F. Schuster, & L. Watt. 2009. Light availability and soil source influence ectomycorrhizal fungal communities on oak seedlings grown in oak- and hemlock-associated soils. Canadian Journal of Forest Ecology 39: 1247-1258.

United States Geological Survey and Virginia Division of Mineral Resources. 1985. Rocky Mount Quadrangle, Virginia – Franklin County, 7.5-minute series, 36079-H8-TF-024.

Virginia Department of Conservation and Recreation. 2012. The natural communities of Virginia: classification of ecological community groups. http://www.dcr.virginia.gov/natural_heritage/natural_communities/ncTIIIj.shtml. (Accessed 1 March 2013).

Virginia Department of Conservation and Recreation. 2013. Grassy Hill Natural Area Preserve. http://www.dcr.virginia.gov/natural_heritage/natural_area_preserves/grassyhill.shtml. (Accessed 1 March 2013).

Walker, J. F., O. K. Miller, Jr., & J. L. Horton. 2008. Seasonal dynamics of ectomycorrhizal fungus assemblages on oak seedlings in the southeastern Appalachian Mountains. Mycorrhiza 18: 123-132.

Wilcox, C. S., J. W. Ferguson, G. C. J. Fernandez, & R. S. Nowak. 2004. Fine root growth dynamics of four Mojave Desert shrubs as related to soil and microsite. Journal of Arid Environments 56: 129-148.

Worley, J. F., & E. Hacskaylo. 1959. The effects of available soil moisture on the mycorrhizal association of Virginia pine. Forest Science 5: 267-268.

Yahner, R. H. 2000. Eastern Deciduous Forest Ecology and Wildlife Conservation. University of Minnesota Press, Minneapolis, MN. 295 pp.

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Dragonflies and Damselflies of Albemarle County, Virginia (Odonata)

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ABSTRACT

The Odonata fauna of Albemarle County, Virginia has been poorly documented, with approximately 20 species on record before this study. My observations from 2006 to 2014, along with historical and other recent records, now bring the total species count for the county to 95. This total includes 64 species of dragonflies, which represents 46% of the 138 species known to occur in Virginia, and 31 species of damselflies, which represents 55% of the 56 species known to occur in Virginia. Also recorded here are the observed date ranges for adults of each species and some observational notes.

Key words: Odonata, dragonfly, damselfly, Albemarle County, Virginia.

INTRODUCTION

For many counties in Virginia, there has been little effort to systematically survey the insect order Odonata (dragonflies and damselflies). As a resident of Albemarle County, I felt that I was in a position to make a sustained effort to remedy the virtual lack of information for this county. Prior to my survey, only about 20 species had been documented in this county (Kennedy, 1977; Carle, 1982; Roble, 1994; Roble et al., 1997; S. Roble, unpub. data). This annotated checklist is meant to bring together both my own observations of Odonata in Albemarle County, Virginia, and other reliable records.

STUDY AREA

Albemarle County (Fig. 1) is centrally located in the Commonwealth of Virginia, with Charlottesville being its largest city. The county lies within the Piedmont physiographic province, except for the northwestern border, where the Blue Ridge Mountains, Pasture Fence Mountain, and Bucks Elbow Mountain are in the Blue Ridge physiographic province. The highest point in the county is 990 m above sea level at the peak of Loft Mountain in the northwest corner. From the foot of the Blue Ridge eastward, the topography is typical of the Piedmont, with the elevation of the plateau generally between 150 and 200 m, trending lower toward the

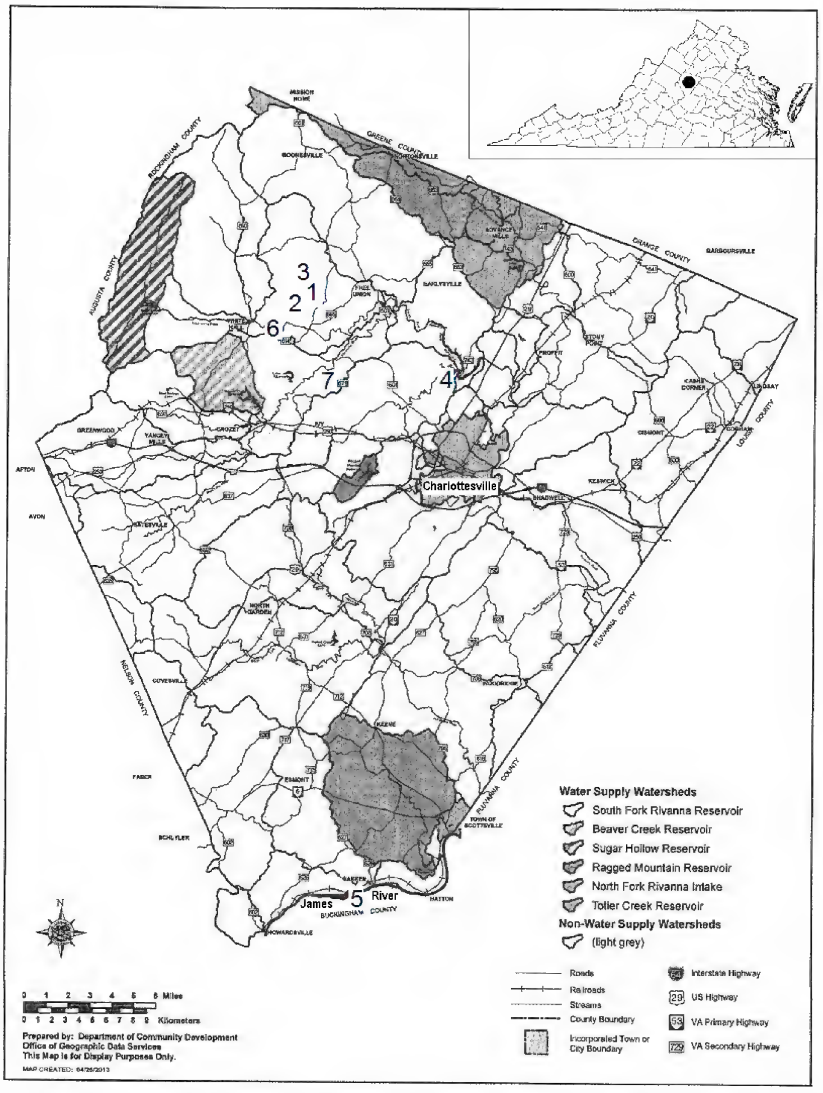

Fig. 1. Map of Albemarle County, Virginia showing primary sampling sites during this study: 1. Lowell pond; 2. Childress/Payne pond; 3. Chapel Springs Farm pond; 4. Ivy Creek Natural Area; 5. James River at Warren; 6. Moormans River; 7. Mechums River.

James River and the Fluvanna County line, where the elevation is about 75 m. There are several groups of outlying mountains, including Fox Mountain in the northwest and the Ragged Mountains south of Charlottesville, with elevations ranging from 365 to over 730 m. Southwestern Mountain lies just east of Charlottesville and runs from the northeast of the county toward the southwest, with the highest point being over 550 m. The county is a mix of urban and suburban development, farmland, and primary and secondary growth forests.

Albemarle County is drained primarily by the James River and three of its tributaries (Rockfish, Hardware, and Rivanna rivers) and the numerous smaller streams that feed them. The headwaters of the South Anna River (York River drainage) extend into this county over a mile near Barboursville. All of the tributaries of the James River flow in entrenched, meandering channels, which cross the structural trend of this area. Their drainage pattern has, in places, a well-defined trellis pattern, and in other places a poorly defined pattern of the same type (Nelson, 1962).

Albemarle County has no natural lakes, but there are many man-made impoundments, including the South Rivanna Reservoir, Sugar Hollow Reservoir, Beaver Dam Creek Reservoir, Totier Creek Reservoir, and Ragged Mountain Reservoir. There are also numerous private ponds, some with flooded forests and beaver activity, some full of cattails (*Typha* spp.), some surrounded by alders (*Alnus* spp.), and others standing

in pastures, their banks trampled by cattle.

Although I have surveyed many private ponds in Albemarle County, I have paid special attention to three of them (see Fig. 1) with somewhat different characteristics. The Chapel Springs Farm pond (38.15714° N, 78.61095° W) is fed by a branch of Rocky Creek. Where the creek enters the pond, there is a shallow swampy area with alders, grasses, rushes, and a few cattails. The pond itself has many water lilies (*Nymphaea* spp.). Along Blufton Mill Road, the Lowell pond (38.13886° N, 78.62161° W) is a small, somewhat overgrown pond that has many cattails in the shallows and is quite weedy around. The Childress/Payne pond (38.14942° N, 78.62161° W) was built in 2007, had no fish in the first season, and is less grown up than the others.

The Mechums and Moormans are small rivers that drain the western part of the county. The Moormans is somewhat rockier and the Mechums carries more sediment. These two join near Free Union to form the South Fork of the Rivanna River. These rivers, along with the much larger James River on the county's southern border, have received most of my focus for riverine habitat.

METHODS

With a few exceptions, my species records are based on identification of specimens that I have collected with a standard insect net (adults) or a D-shaped collecting net (larvae) and that have been verified by Steve Roble of the Virginia Natural Heritage Program. Adults have been preserved with acetone and larvae preserved in a 70% ethyl alcohol solution. I have attempted to collect adult specimens of every species, but there are several species for which I have only obtained larvae and/or exuviae. In one case (*Libellula axilena*), my only record is a photograph. I have also included historical and personal records for Albemarle County provided by Steve Roble.

In a few cases, I have raised larvae to adulthood in order to have more definitive identifications. Individual larvae were kept in screen enclosures set in two to three inches of water in a plastic tub with aeration. The larvae were able to crawl up the screen and out of the water when ready to emerge.

RESULTS

My observations from 2006 to 2013, along with historical and other recent records, bring the total Odonata species count for Albemarle County to 95. This total includes 64 species of dragonflies, which represents 46% of the 138 species known to occur in Virginia, and 31 species of damselflies, which represents 55% of the 56 species known to occur in Virginia (S. Roble, unpub. data). The following annotated checklist is arranged alphabetically within families. Each species is listed with observation notes followed by the first and last observed flight dates for the county in parentheses and the nature of specimens collected: A (adult), L (larva), E (exuvia). Unless otherwise noted, specimens are in my personal collection.

ANISOPTERA (Dragonflies)

Petaluridae (Petaltails)

Tachopteryx thoreyi (Gray Petaltail)

I have seen this species along the wooded stream bottom of Rocky Creek on Chapel Springs Farm, hanging vertically on tree trunks, and on the gray wood siding of our house. Every day from 11-23 July 2004, I observed an adult hunting from the gray gravel of our driveway. I watched one on a tree branch eating a Lancet Clubtail (*Gomphus exilis*). The species is not common in the county, and I typically only see a few individuals each year, with my highest one-day count being five. (May 16 to July 23; A)

Aeshnidae (Darners)

Aeshna umbrosa (Shadow Darner)

Male Shadow Darners patrol shady, heavily vegetated, sluggish streams in the fall, and I have consistently seen them at the Lowell pond outlet stream and other slow shady streams, where females deposit eggs. I have also observed Shadow Darners flying abroad in open fields, and I saw a hunting swarm of several dozen on 5 September 2012. (September 5 to November 21; A)

Aeshna verticalis (Green-striped Darner)

I am only aware of one other Virginia record of this more northern species, and that was from Highland County (Roble et al., 2009). I captured an adult male on 21 October 2006 in tall grass near the Lowell pond. There is no evidence that this species breeds in the area; this individual was likely migrating or wandering late in the season. (October 21; A)

Anax junius (Common Green Darner)

This species is common at local ponds where the

males can be seen assertively patrolling the edges. Presumably due to its migratory habits, adults can be seen in late March before other species have emerged. From mid-September to early October it is common to see large numbers hawking insects. These are sometimes intermixed with Black Saddlebags (*Tramea lacerata*). In 2007, I observed a newly built pond, which was just filling up in mid-May. By July 14th there were exuviae on plant stems at the water's edge, indicating that individuals had completed their life cycle from egg to adult within two months. (March 17 to October 15; A, E)

Anax longipes (Comet Darner)

Comet Darners are somewhat uncommon but I have seen them patrolling several farm ponds in summer and have collected one larva. Males are aggressive and fly rapidly both along the shore and out over the open water. (May 16 to August 28; A, L)

Basiaeschna janata (Springtime Darner)

Springtime Darners patrol the edges of streams that range from a meter across to as large as the James River. I have sometimes seen them flying along the shores of farm ponds or flying along woodland paths away from water. I have also captured the larvae in streams both small and large and found an exuvia at the Childress/Payne Pond. (March 31 to June 7; A, L, E)

Boyeria vinosa (Fawn Darner)

This species is quite common in the late summer and fall on the Moormans and Mechums rivers where they fly close to the shady banks among the roots and snags, especially late in the day. I have also caught females out in the middle of streams over riffles. The larvae can be reliably found in the mud under river banks. Between 9 and 16 July 2009, I discovered three individuals trapped in netting that had been placed over blueberry bushes. These were far from any stream of the type in which they breed. (June 7 to October 10; A, L)

Epiaeschna heros (Swamp Darner)

I have seen Swamp Darners at Chapel Springs Farm pond, in woodland clearings, and in my own yard, but they were most commonly observed hawking over fields at Warren near the James River. Here the adults make rapid forays over the fields, often 2-7 m above the ground, with occasional rest periods in trees at the fields' edges. (May 21 to June 24; A, E)

Gomphaeschna antilope (Taper-tailed Darner)

Carle (1982) listed a male specimen in the collection of Virginia Commonwealth University that was collected by M. Zimmerman on 13 June 1975 in Charlottesville. I have not found this species or the closely related Harlequin Darner (*G. furcillata*) in Albemarle County. (June 13)

Nasiaeschna pentacantha (Cyrano Darner)

In Albemarle County, I have only seen this species at the Ivy Creek Natural Area, where the stream along the Red Trail meets the South Rivanna Reservoir. Males patrol back and forth above the sluggish shady stream, covering and recovering a 30 or 40 foot section of the creek. (July 7 to July 18; A)

Gomphidae (Clubtails)

Arigomphus villosipes (Unicorn Clubtail)

At Chapel Springs Farm Pond and a heavily vegetated temporary pond in a field at Warren, I have seen Unicorn Clubtails in late May and early June perching on lily pads or other vegetation growing in the water. I caught a fairly mature larva in the Chapel Springs Farm pond on 20 September 2008. (May 24 to July 4; A, L)

Dromogomphus spinosus (Black-shouldered Spinyleg)

Black-shouldered Spinylegs can be seen near streams and rivers of all sizes: tiny woodland streams, the Mechums, Moormans, and Rivanna Rivers, and the James River at Warren. They perch on the ground along the shores and also on plants and bushes. This is a common dragonfly and can be seen over a longer season than many of the other clubtails. (May 23 to September 9; A, L, E)

Erpetogomphus designatus (Eastern Ringtail)

This species is abundant in the summer on the James River, and can be seen in great numbers flying out over the water. Adults can also be found in forests and fields near the river. They are present on the Rivanna River and at the Ivy Creek Natural Area on the South Fork Reservoir. I have seen them upstream on the Moormans River nearly to the Free Union Road, but they are much less common on the smaller rivers than on the James. Larvae are relatively easily caught in silty places in the James River. (May 16 to September 9; A. L)

Gomphus abbreviatus (Spine-crowned Clubtail)

Spine-crowned Clubtails emerge from the James River at Warren in great numbers in mid- to late April, leaving exuviae on the banks and on roots and branches sticking out of the water. For a few weeks the adults can be seen in the grasses and bushes back from the water. I have seen them up the smaller rivers as far as the Millington Bridge on the Moormans River. (March 31 to June 4; A, L, E)

Gomphus dilatatus (Blackwater Clubtail)

This species is present in the James River at Warren where I collected a fairly mature larva on 7 October 2010 and have since collected adults in the spring and summer. Until recently, the range of this species was not considered to extend this far north (Roble, 2014). (June 7 to July 12; A, L)

Gomphus exilis (Lancet Clubtail)

Sitting on or near the ground, Lancet Clubtails are common near ponds and sluggish streams during their flight season. This is a widespread species in Albemarle County. (April 21 to July 8; A, L)

Gomphus lividus (Ashy Clubtail)

From mid-April through May, Ashy Clubtails are common both in vegetation near farm ponds and slow streams, and sometimes far from water in grassy fields and yards. I observed one eating a small grasshopper in my yard. I have collected larvae in both ponds and slow streams. (March 31 to June 20; A, L, E)

Fig. 2. Adult female Rapids Clubtail (*Gomphus quadricolor*) from the Moormans River, Albemarle, County, Virginia.

Gomphus quadricolor (Rapids Clubtail)

I first found a Rapids Clubtail (Fig 2) in 2007 near the confluence of the Moormans and Mechums rivers. I have since found larvae in both of those rivers. On 24 May 2009, I observed a substantial emergence of adults along the Moormans River about halfway between Millington and White Hall. Dozens of tenerals were clinging to vegetation near the river and fluttering in the grass of a nearby field. Over the following several weeks I continued to find adults at that location and several miles downstream, generally in fields and low shrubs a short distance from the water. (May 24 to June 20; A, L)

Gomphus rogersi (Sable Clubtail)

I have collected larvae in the inlet stream to the Chapel Springs Farm pond (7 March 2009 and 27 March 2010) and an adult (25 May 2009) from a heavily shaded small stream that feeds into the Moormans River about halfway between Millington and White Hall. (May 25; A, L)

Gomphus vastus (Cobra Clubtail)

In early May, Cobra Clubtails emerge from the James River in very large numbers. They are very common at Warren, where they can be found in tall grasses and low in the trees. I have caught many larvae in the river there. (April 20 to July 13; A, L, E)

Gomphus viridifrons (Green-faced Clubtail)

In Virginia, this species is mostly known from the southwestern part of the state (Carle, 1982; Roble et al., 1997). I have collected both larvae and adults at the James River at Warren. There are also records east of Albemarle County along the James River as far downstream as the City of Richmond (S. Roble, unpub. data), so the James supports a population of this species east of the Blue Ridge Mountains. (May 3 to May 11; A, L)

Hagenius brevistylus (Dragonhunter)

I have seen Dragonhunters flying over the water and perching on rocks or on branches in streams and rivers ranging from the James, Rivanna, Moormans, and

Mechums rivers, to the small inlet stream at the Chapel Springs Farm Pond. I generally see them singly, but they are widespread on rivers and streams. I watched one laying eggs on the pavement on East Jefferson Street in Charlottesville, presumably because the dark color of the street resembles a stream. The large flattened larvae are relatively easily found in half-rotted sticks and leaves at the bottom of streams as well as under rocks in swifter water. (May 28 to October 17; A, L, E)

Ophiogomphus incurvatus (Appalachian Snaketail)

My only record is a larva collected from the wooded inlet stream at Chapel Springs Farm pond on 14 February 2009. (L)

Ophiogomphus susbecha (St. Croix Snaketail)

A very small number of mature adults of this species have been captured in Virginia (S. Roble, pers. comm.), but exuviae are relatively easily found along the James River in April. In Albemarle County, I collected many fresh exuviae on the banks of the James River at Warren from March 31 to April 16. Steve Roble (pers. comm.) has also collected exuviae of this species along the James River at Warren as well as at Hattons Ferry and Scottsville. (E)

Progomphus obscurus (Common Sanddragon)

On sandy banks and sandbars in streams, from small woodland streams to the James River at Warren, this is a common species. On 25 May 2008, I found a number of exuviae on a sandy bank in the Moormans River and found one teneral that was just emerging. This is the earliest date on which I have observed them in the county. (May 25 to July 30; A, L, E)

Stylogomphus albistylus (Least Clubtail)

I have found adults and larvae along the Moormans River from its confluence with the Mechums River upstream to the dam at Sugar Hollow Reservoir, as well as on Jones Run. I have collected larvae from the James River at Warren. (June 1 to July 15; A, L)

Stylurus laurae (Laura's Clubtail)

On both 3 May 2011 and 11 May 2012, I collected one larva in the James River at Warren, about 50 m upstream from Ballinger Creek. The latter specimen emerged on 14 June. I captured a teneral female at the same location on 20 June 2013. (June 20; A, L)

Stylurus plagiatus (Russet-tipped Clubtail)

On 25 June 2008, Steve Roble (pers. comm.) observed one male on the North Fork of the Rivanna River, east of U.S. Route 29. (June 25)

Stylurus spiniceps (Arrow Clubtail)

I have not observed adults, but have collected many larvae from the James River at Warren. Roble et al. (1997) found this species along the Mechums River near Owensville on 18 October 1993. On 19 October 2006, Steve Roble (pers. comm.) observed several *Stylurus* males along the Rivanna River near Shadwell that were probably *S. spiniceps.* (October 18; L)

Cordulegastridae (Spiketails)

Cordulegaster bilineata (Brown Spiketail)

I have captured this species in a shallow, weedy part of the inlet stream to the Chapel Springs Farm pond and in the marshy area at the outlet of the Lowell pond. At the Chapel Springs inlet stream, the male perched repeatedly on one of several plants from which it made short flights. (April 21 to June 3; A)

Cordulegaster erronea (Tiger Spiketail)

While crossing a small, sandy bottomed woodland stream (<1 m wide) that leads eventually into Chapel Springs Farm pond, I captured a Tiger Spiketail that was flying rapidly along the stream. Since that time I have caught larvae in that stream and in similar streams in the immediate vicinity. (July 23; A, L)

Cordulegaster maculata (Twin-spotted Spiketail)

This is the common Spiketail in Albemarle County. I have found them along the edges of woodlands, on bushes in my yard, on woodland paths, and in a swampy area below the Lowell pond (newly emerged on a cattail stalk). The larvae are fairly easily found in small sandy-bottomed woodland streams, in the smaller ones sometimes in conjunction with *C. erronea*. (April 7 to May 29; A, L, E)

Macromiidae (Cruisers)

Didymops transversa (Stream Cruiser)

This common early spring species cruises back and forth along the banks of small streams (Chapel Springs Farm pond inlet stream) and large rivers (James River

at Warren). It shares both habitat and season with the Springtime Darner. I observed a teneral emerging on a stalk of grass on the edge of the Childress/Payne pond. (April 7 to June 4; A, L, E)

Macromia illinoiensis (Swift River Cruiser)

I have seen adults of this species on medium (Moormans and Mechums) and large rivers (James) where they cruise rapidly up and down the river. In between these patrols, they appear to perch high in the trees. I have also found the larvae in smaller streams, including the inlet to Chapel Springs Farm pond. I have occasionally seen adults cruising along roadways as though those roadways were streams and have seen them far from water patrolling grassy areas. I have occasionally seen one along the shores of a farm pond. (May 24 to September 9; A, L)

Corduliidae (Emeralds)

Epitheca cynosura (Common Baskettail)

Common Baskettails are abundant at farm ponds and creeks in the spring, where males defend territories along the banks. They are also common in yards and gardens away from water. (March 24 to June 20; A, L, E)

Epitheca princeps (Prince Baskettail)

Most farm ponds seem to have one male patrolling out over the water, often far from the shore. They are fairly common on the Moormans, Mechums, and Rivanna Rivers, and quite common on the James River. Larvae are easily netted in silty deposits in the James River. (April 30 to August 28; A, L, E)

Helocordulia selysii (Sely's Sundragon)

I captured an adult female along Preddy Creek at Gilbert. It was perched on a twig close to the ground in the Box Elder (*Acer negundo*) lowland woods. (April 27; A)

Helocordulia uhleri (Uhler's Sundragon)

I have seen a few individuals of this species most years at the inlet stream leading to Chapel Springs Farm Pond. The stream is wooded and fairly shady at that point. Males patrol rapidly and erratically. I have also captured an adult along a sunny driveway far from water. Not easily captured, this dragonfly is both wary and quick. (April 15 to May 14; A)

Neurocordulia virginiensis (Cinnamon Shadowdragon)

Although I expected to find several species of this genus, after spending considerable time and effort in late May and early June in the James River at Warren, all of the larvae, exuviae, and adults that I have collected are *N. virginiensis*. The adults fly out over the river from about 1830 h until dark, with the greatest activity about 45 minutes before dark. (May 24 to June 14; A, L, E)

Libellulidae (Skimmers)

Celithemis elisa (Calico Pennant)

This abundant species can be seen in farm ponds and grassy fields throughout the county. (May 2 to September 23; A, L, E)

Celithemis eponina (Halloween Pennant)

Halloween Pennants are commonly seen at farm ponds and nearby fields in late summer and early fall. I have also seen them on the South Rivanna Reservoir and James River. Pairs fly in tandem low over the water as the female lays eggs. I have observed a Largemouth Bass (*Micropterus salmoides*) capture a pair as they touched the water. (July 7 to October 10; A)

Celithemis fasciata (Banded Pennant)

This species (Fig, 3) is less common than *C. elisa*, but still fairly easily found at farm ponds. (May 14 to October 6; A)

Celithemis verna (Double-ringed Pennant)

This pennant is somewhat uncommon in Albemarle County, but can be found at ponds, usually sitting

Fig. 3. Adult male Banded Pennant (*Celithemis fasciata*) from the Childress/Payne pond, Albemarle, County, Virginia.

on the rushes farthest from the shore. Their flight is much quicker than the other *Celithemis* species, and they tend to dart quickly from their perches to grab prey and then return. I have seen them at the Childress/Payne pond, Lowell pond, and Chapel Springs Farm pond, but never in large numbers. (June 5 to July 15; A)

Dythemis velox (Swift Setwing)

My only record of this species in Albemarle County is an adult captured on 7 July 2007 at the Ivy Creek Natural Area. It was perching on a dead alder branch out over the reservoir and returned repeatedly to that same spot between forays. This is a southern species with only a handful of records in the state (Bedell & Chazal, 1999; S. Roble, pers. comm.). (July 7; A)

Erythemis simplicicollis (Eastern Pondhawk)

This common dragonfly is routinely found at ponds and still water where it perches in vegetation near and in the water. It is an aggressive predator, and I have observed one eating an Eastern Amberwing (*Perithemis tenera*). (April 21 to October 6; A, L)

Erythrodiplax minuscula (Little Blue Dragonlet)

I have seen this species only twice in the county, both times at the Childress/Payne pond, perched in low vegetation near the water. (July 20 to September 15; A)

Ladona deplanata (Blue Corporal)

In the early spring, this is an abundant species near ponds and lakes, where it tends to sit on or near the ground, with wings often held slightly downward. The larvae are easily found around pond edges. (April 7 to June 20; A, L, E)

Libellula auripennis (Golden-winged Skimmer)

My only location for this species in the county is the Childress/Payne pond, where it has been regularly seen for several years in fairly small numbers. (June 5 to June 30; A)

Libellula axilena (Bar-winged Skimmer)

On 18 June 2006, I observed a Bar-winged Skimmer return many times to the branches of a dead tree lying in the water at the Chapel Springs pond inlet stream. It was noticeably wary and I was unable to capture it. (June 18; photograph)

Libellula cyanea (Spangled Skimmer)

This beautiful skimmer is common in marshy areas and around ponds. It is particularly common at Chapel Springs Farm pond, which has a large marshy area at the upper end of the pond. Pam Hunt (pers. comm.) found a teneral female in Charlottesville on the rather early date of 23 April 2007. (April 23 to August 15; A)

Libellula incesta (Slaty Skimmer)

This skimmer is widespread and abundant at farm ponds, reservoirs and lakes, and the vegetation around the shores is crowded with them. The larvae are easily captured in the shallow waters. (May 31 to October 6; A, L)

Libellula luctuosa (Widow Skimmer)

This familiar dragonfly of summer is very common near ponds and lakes throughout the county. Females are common in fields away from the water. (May 24 to October 14; A, L)

Libellula pulchella (Twelve-spotted Skimmer)

Twelve-spotted Skimmers are present in the county from early May to late September at a variety of farm ponds, but I only see them occasionally, and then generally only one or two at a time. (May 2 to September 29; A, L)

Libellula semifasciata (Painted Skimmer)

I have only seen this very distinctive species twice in Albemarle County, and was able to collect an adult at the Childress/Payne pond as it perched in the reeds at the pond's edge. (May 9 to May 25; A)

Libellula vibrans (Great Blue Skimmer)

I have occasionally seen this species near the Chapel Springs Farm pond and more often near the James River at Warren. Based on my observations, it is somewhat uncommon in Albemarle County. (June 3 to August 16; A)

Pachydiplax longipennis (Blue Dasher)

In the vegetation at the edge of ponds, lakes, and slow streams, this species is abundant and widespread in the county. Males aggressively confront intruders. (May 15 to October 14; A, L)

Pantala flavescens (Wandering Glider)

I have seen this wide-ranging dragonfly in hayfields, parking lots, and over athletic fields and roads. They breed in the Childress/Payne farm pond, and I have found the exuviae on plants at the pond's edge and tenerals flying weakly in the grass near the pond. (June 21 to October 7; A, E)

Pantala hymenaea (Spot-winged Glider)

My observations indicate that this species is less common than *P. flavescens* in Albemarle County, but it also breeds in the Childress/Payne farm pond. (July 18 to August 7; A)

Perithemis tenera (Eastern Amberwing)

Perching on low vegetation in the water and flying forays just above the surface of the water, the Eastern Amberwing can reliably be found on ponds and lakes throughout the county. I have also seen them congregating in shrubs near the education center at the Ivy Creek Natural Area, hundreds of meters from the water. I observed one being eaten by an Eastern Pondhawk (*Erythemis simplicollis*). (June 4 to September 16; A)

Plathemis lydia (Common Whitetail)

Due to its abundance, extremely broad distribution, and habit of perching on or near the ground, this is the dragonfly most often seen by the layperson. I have observed them perching in yards, woods, and all around ponds and lakes. (April 14 to September 16; A, L)

Sympetrum ambiguum (Blue-faced Meadowhawk)

Carle (1982) listed two male specimens in the collection of Virginia Tech that were captured by Mary E. Davis on 1 September 1937 in Charlottesville. I have not encountered this species in the county.

Sympetrum vicinum (Yellow-legged Meadowhawk)

In 2011, I began seeing adults at the Childress/ Payne pond on June 26, with all of them appearing to be females. They were not present in large numbers but could consistently be found throughout the rest of the summer. As other common species die out in the fall, this becomes the most common dragonfly on farm ponds around the county, persisting quite late in the season. During a mild fall, I found a live adult on 23 December 2006 at Chapel Springs Farm pond. (June 25 to December 23; A)

Tramea carolina (Carolina Saddlebags)

Although not seen in large numbers, this species is fairly widespread on ponds and lakes where it flies a few feet above the water and along the shores. (April 26 to August 28; A, L)

Tramea lacerata (Black Saddlebags)

This is the more common of the two *Tramea* species found in Albemarle County, being reliably seen at ponds and lakes. It also congregates with Common Green Darners (*Anax junius*) in September in what appear to be migrating groups, hawking over open fields. (May 11 to October 15; A)

ZYGOPTERA (Damselflies)

Calopterygidae (Broad-winged Damsels)

Calopteryx angustipennis (Appalachian Jewelwing)

Ballinger Creek flows into the James River at Warren, and I have observed Appalachian Jewelwings along that shady, sandy, slow-flowing stream. I have also found them along the banks of the James near Ballinger Creek. (April 27 to June 7; A)

Calopteryx dimidiata (Sparkling Jewelwing)

My only Albemarle County record of this species is an adult captured on 6 June 2010 at Warren sitting on a branch overhanging the James River at dusk. Steve Roble (pers. comm.) found this species on 25 June 2008 along the North Fork of the Rivanna River just east of U.S. Route 29. (June 6 to June 25; A)

Calopteryx maculata (Ebony Jewelwing)

This is our most common Jewelwing and is found along the banks of shady woodland streams throughout the county. These streams include the smallest forest trickles as well as the James River. (April 27 to August 23; A, L)

Hetaerina americana (American Rubyspot)

The American Rubyspot is found along the Moormans, Mechums, and Rivanna rivers, but is particularly abundant on the James River. Groups of them congregate around plants growing in sandy

shallow places in the water. (May 11 to October 7; A, L)

Hetaerina titia (Smoky Rubyspot)

This species is found in the same locations and habitat as *H. americana*, although it is much less common than that species. I associate it more with willows and other tree branches overhanging the water than with plants growing in the water. (June 12 to October 7; A)

Lestidae (Spread-winged Damsels)

Archilestes grandis (Great Spreadwing)

Kennedy (1977) reported that the first Virginia specimen of this primarily western species was collected in Charlottesville in October 1947. I have seen this damselfly at the Lowell Pond outlet stream, which is a typical spreadwing habitat. I have also captured it flying purposefully along Blufton Mill Road, far from any water. Those are my only two records of this species in the county. (September 30 to October 19; A)

Lestes australis (Southern Spreadwing)

I have found adults in a shallow overgrown temporary pond at Warren, several hundred meters from the James River. They generally perched on vegetation growing out of the water. (April 19 to May 24; A)

Lestes eurinus (Amber-winged Spreadwing)

The year that the Childress/Payne pond was constructed, Amber-winged Spreadwings were abundant there. Fish were introduced the next season and few of these damselflies were present. As the fish multiplied in subsequent years, this species is now only occasionally seen there. Amber-winged Spreadwings are aggressive predators of smaller damselflies, and I have observed them eating Orange Bluets (*Enallagma signatum*) and Fragile Forktails (*Ischnura posita*). (June 8 to July 14; A)

Lestes rectangularis (Slender Spreadwing)

My records for this species are from the Ivy Creek Natural Area, in a small marshy area just off the Red Trail, from the Childress/Payne pond, and also from the James River at Warren. (June 4 to August 25; A)

Lestes vigilax (Swamp Spreadwing)

In Albemarle County, this is the most common Spreadwing. It can be commonly found in dense vegetation at the edges of farm ponds, and I have seen many of them in the wet woods at Gilbert Crossing. They are most common in the late summer, but adults can be seen in May. (May 17 to October 10; A)

Coenagrionidae (Narrow-winged Damsels)

Amphiagrion saucium (Eastern Red Damsel)

Reported by Roble (1994) from Albemarle County on the basis of a specimen collected by Richard Hoffman in May 1948 in Charlottesville (S. Roble, pers. comm.). I have not encountered this species in the county.

Argia apicalis (Blue-fronted Dancer)

This species is found along the banks of the Moormans, Mechums, Rivanna, and James rivers. I have seen females in forests above the South Rivanna Reservoir at the Ivy Creek Natural Area. (May 16 to July 28; A)

Argia fumipennis violacea (Violet Dancer)

From May to October this is a common and widespread species, typically found in vegetation around ponds and slow-moving streams. (May 15 to October 3; A)

Argia moesta (Powdered Dancer)

Sitting on rocks in streams and rivers of all sizes, Powdered Dancers are quite common around flowing water. I have occasionally seen them at farm ponds, including the Lowell pond and the Childress/Payne pond. (May 16 to September 23; A, L)

Argia sedula (Blue-ringed Dancer)

In overhanging plants along the Moormans, Mechums, Rivanna, and James rivers, this damselfly is widespread. (June 7 to September 22; A)

Argia tibialis (Blue-tipped Dancer)

I have seen Blue-tipped Dancers on both the Moormans and James rivers. They are not as common in the county as some of the other *Argia* species. (June 7 to July 14; A)

Argia translata (Dusky Dancer)

This is another river species found on the Moormans, Mechums, and Rivanna rivers, typically in vegetation in or near the water. (May 25 to August 26; A)

Enallagma aspersum (Azure Bluet)

I have seen Azure Bluets at both the Lowell pond and the Childress/Payne pond, but they were particularly abundant at the latter pond before fish were first introduced. They appeared in large numbers shortly after that pond was built, but as the fish have become established, their numbers have become much reduced. (April 21 to September 23; A)

Enallagma basidens (Double-striped Bluet)

From early May until October, this bluet is widely found at farm ponds, including Chapel Springs Farm pond, Childress/Payne pond, and the Lowell pond. (May 2 to October 14; A)

Enallagma civile (Familiar Bluet)

From late May through the summer I see Familiar Bluets around the edges of farm ponds. Their numbers seem greater by September and this is the latest damselfly that I have observed in the fall. (May 24 to November 21; A)

Enallagma daeckii (Attenuated Bluet)

I have collected this species at the Lowell pond and seen it there one other time. This is the most inland record known in Virginia (Lam, 2004; S. Roble, pers. comm.). (June 5 to July 15; A)

Enallagma divagans (Turquoise Bluet)

In May and June I see this species around farm ponds and in the slow-moving inlet stream at the top of Chapel Springs Farm pond. (May 6 to June 10; A)

Enallagma exsulans (Stream Bluet)

As well as on the Moormans, Mechums, and James rivers, I have seen this common bluet on farm ponds. (May 24 to September 3; A)

Enallagma geminatum (Skimming Bluet)

This is a common farm pond bluet, typically found close to the water, on or near emergent vegetation. (May 2 to September 17; A)

Enallagma signatum (Orange Bluet)

Common at farm ponds over a relatively long season, I often see Orange Bluets holding onto grasses or rushes just above the water, with their bodies held horizontal like a pennant extended from a pole. (April 21 to October 14; A)

Enallagma traviatum traviatum (Slender Bluet)

This is another common denizen of farm ponds in the county. (May 25 to July 12; A)

Enallagma vesperum (Vesper Bluet)

I have seen Vesper Bluets at both the Lowell pond and the Childress/Payne pond at around dusk. They typically alight on floating mats of pondweed out in the water, but I also captured a mating pair in a small tree on the shore. (May 22 to September 15; A)

Ischnura hastata (Citrine Forktail)

I only see this damselfly occasionally, and it tends to be somewhat inconspicuous, low in heavy vegetation in damp places around farm ponds, including the Lowell pond, Childress/Payne pond, and Chapel Springs Farm pond. (April 21 to September 16; A)

Ischnura kellicotti (Lilypad Forktail)

My only record is of several adults perched on lily pads at Chapel Springs Farm pond. (May 30; A)

Ischnura posita (Fragile Forktail)

This is by far the most common of the forktails in Albemarle County. It is likely to be found low in heavy vegetation near any body of water. It is abroad from spring through fall. (March 22 to October 19; A)

Ischnura verticalis (Eastern Forktail)

Much less common than the Fragile Forktail, this damselfly can often be found at farm ponds in similar habitat. (March 24 to November 8; A)

DISCUSSION

Understanding of the distribution of Odonata species in Virginia has come from a combination of somewhat spotty data and educated extrapolation of that data. This paper combines the known historical records with new observations to present a more complete and systematic record for Albemarle County, showing that nearly half of the Virginia Odonata fauna occurs in this county.

It is likely that additional species are present in the county but yet to be documented. Some of the possible species to be discovered include *Gomphaeschna furcillata* (Harlequin Darner), *Boyeria grafiana* (Ocellated Darner), *Gomphus lineatifrons* (Splendid Clubtail), *Lanthus vernalis* (Southern Pygmy Clubtail), *Stylurus amnicola* (Riverine Clubtail), *Ophiogomphus rupinsulensis* (Rusty Snaketail), *Cordulegaster obliqua* (Arrowhead Spiketail), *Somatochlora linearis* (Mocha Emerald), *Neurocordulia obsoleta* (Umber Shadowdragon), *Libellula flavida* (Yellow-sided Skimmer), *Sympetrum rubicundulum* (Ruby Meadowhawk), *Lestes congener* (Spotted Spreadwing), *Lestes forcipatus* (Sweetflag Spreadwing), *Argia bipunctulata* (Seepage Dancer), *Chromagrion conditum* (Aurora Damsel), and *Nehalennia integricollis* (Southern Sprite). Locations especially worthy of further study include farm ponds in the southeastern portion of the county that might be at the western range limit for some species, mountain streams like Jones Run and the North and South Forks of the Moormans River, and both forested and open seepage areas. I believe there are additional species to be found in and around the James River.

There remains a large opportunity for naturalists around the state to make a significant contribution to our knowledge of Odonata distribution. It is important to both document this information and to make it available to others so that we can advance our collective knowledge of these remarkable animals.

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LITERATURE CITED

Bedell, P., & A. Chazal. 1999. *Dythemis velox*, a new species for Virginia. Argia 11(3): 4-5.

Carle, F. L. 1982. A contribution to the knowledge of the Odonata. Ph.D. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA. 1,095 pp.

Kennedy, J. H. 1977. The occurrence of *Archilestes grandis* Rambur (Zygoptera: Lestidae) in Virginia. Entomological News 88: 215-216.

Lam, E. 2004. Damselflies of the Northeast. Biodiversity Books, Forest Hills, NY. 96 pp.

Nelson, W. A. 1962. Geology and Mineral Resources of Albemarle County. Virginia. Virginia Division of Mineral Resources Bulletin 77. 92 pp.

Roble, S. M. 1994. A preliminary checklist of the damselflies of Virginia, with notes on distribution and seasonality (Odonata: Zygoptera). Banisteria 4: 3-23.

Roble, S. M. 2014. Distribution and relative abundance of *Gomphus dilatatus* (Blackwater Clubtail) at the northern limit of its range in Virginia. Argia 26(1): 16-18.

Roble, S. M., F. L. Carle, & O. S. Flint, Jr. 2009. Dragonflies and damselflies (Odonata) of the Laurel Fork Recreation Area, George Washington National Forest, Highland County, Virginia: Possible evidence for climate change. Pp. 365-399 *in* S. M. Roble & J. C. Mitchell (eds.), A Lifetime of Contributions to Myriapodology and the Natural History of Virginia: A Festschrift in Honor of Richard L. Hoffman's 80th Birthday. Virginia Museum of Natural History Special Publication No. 16, Martinsville, VA.

Roble, S. M., C. S. Hobson, & D. J. Stevenson. 1997. New distributional records for rare and uncommon Odonata in Virginia. Banisteria 9: 33-42.

Banisteria, Number 43, pages 40-55

Twelve Ground Beetles New to Virginia or the District of Columbia and an Annotated Checklist of the Geadephaga (Coleoptera, Adephaga) from the George Washington Memorial Parkway

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ABSTRACT

One-hundred eighty-four species in 70 genera of geadephagan beetles (183 carabids and one rhysodid) were documented during a nine-year field survey of a national park site (George Washington Memorial Parkway) that spans parts of Fairfax and Arlington counties and the City of Alexandria in Virginia, and the District of Columbia. The capture of *Elaphropus quadrisignatus* (Duftschmid) represents the second record for the New World. Seven species, *E. quadrisignatus*, *Harpalus rubripes* (Duftschmid), *Microlestes pusio* (LeConte), *Platynus opaculus* LeConte, *Pterostichus permundus* (Say), *P. sculptus* LeConte, and *Scarites vicinus* Chaudoir are documented for the first time from the Commonwealth. Seven species, *Anisodactylus dulcicollis* (LaFerté-Sénectère), *Elaphropus anceps* (LeConte), *E. saturatus* (Casey), *Oodes americanus* Dejean, *P. permundus*, *S. vicinus*, and *Tachys potomaca* (Erwin) are documented for the first time from the District of Columbia. The study increases the number of geadephagan beetles known from the Potomac River Gorge to 255 species and the number from Virginia to 543 taxa. Hand picking and Malaise traps proved to be the most successful capture methods of the eight methods employed during the survey. Periods of adult activity, based on dates of capture, are given for each species. Relative abundance is noted for each species based on the number of captures. Notes on morphological characteristics and habitats are given for some species. *Phloeoxena signata* (Dejean) was the only species found in the study area that appears on the state list of rare animals of Virginia. Eight species are adventive to North America.

Key words: Carabidae, Coleoptera, District of Columbia, Geadephaga, ground beetles, national park, new state records, Potomac River Gorge, Virginia.

INTRODUCTION

The Geadephaga (Coleoptera, Adephaga), which includes the families Trachypachidae, Rhysodidae, and Carabidae (including cicindelines) is a large group of primarily polyphagous beetles with estimates of nearly 40,000 species worldwide (Erwin, 1991). The carabids, or ground beetles, represent the vast majority of the group with more than 33,905 described species, and 2,635 species and subspecies inhabiting Nearctic North America (Ball & Bousquet, 2001). The rhysodids, or wrinkled bark beetles contain 355 species, and the trachypachids, or false ground beetles, are represented by only six species found in Chile, northern Eurasia, and the western United States and Canada (Bousquet, 2012).

Even within the Carabidae there is high diversity in body form and habitat preferences. Body lengths range from just over 1 mm to nearly 100 mm. Some species are blind whereas others have large eyes. Some possess well developed wings and are strong fliers. Others are flightless and have short or rudimentary wings, and

some are wing-polymorphic. Carabids occupy nearly every conceivable niche. Some are strong diggers and can be found in subsurface habitats, some are cave specialists, and others are primarily arboreal. They are found in swamps and marshes, upland forests and deserts, from below sea level to 5,300 m elevation (Mani, 1968). It is not uncommon to find carabids in human habitations. Many species overwinter as adults. Adults live two to four years and the life cycle is completed within one year. Pupation occurs in the ground (Ball & Bousquet, 2001). Carabid fossils are common in Quaternary age deposits, many representing extant species, and have been found in sediments as old as the late Tertiary Period (Matthews, 1979; Matthews & Telka, 1997).

The family is popular among collectors worldwide, no less so in Virginia. The first attempt to compile a list of Geadephaga from the Commonwealth was made by Bousquet & Larochelle (1993), who attributed 446 carabid taxa and four rhysodid species to Virginia. Davidson (1995) solidified this list and increased the total to 453 carabid species. Anderson et al. (1995) raised the species tally to 458 species. Knisley & Schultz (1997) added three *Cicindela* bringing the total to 461 species. Hoffman (1997) added one species, *Phloeoxena signata* (Dejean), to the total. Hoffman (1998) added *Pterostichus pensylvanicus* LeConte and deleted *Pterostichus adstrictus* Eschscholtz from the carabid fauna of the Commonwealth. Hoffman & Roble (2000) and Hoffman et al. (2006) added 44 carabid species to the fauna of the Commonwealth, raising the total to 506 species. Evans (2009) added the European exotic *Calosoma sycophanta* (Linnaeus), and Hoffman (2010) added four other carabids. With the publication of Bousquet (2012) the number of Geadephaga recorded from the Commonwealth reached 531 taxa, giving Virginia (tied with Ontario) the fifth most species-rich geadephagan fauna of all political regions in the United States and Canada. Roble & Hoffman (2012) broke the tie with Ontario by the discovery of three carabids and one rhysodid beetle new to the Virginia fauna, bringing the total to 535 taxa (528 species and seven subspecies), including 530 carabids and five rhysodids. Roble & Hoffman (2012) also provided a table summarizing the citations for the various additions and deletions to the Virginian geadephagan list since the records added by Hoffman et al. (2006).

This study sought to add to the distributional knowledge of the geadephagan fauna by compiling records, documented with a voucher specimen, from a national park in northern Virginia, George Washington Memorial Parkway (GWMP), and to determine whether any federally or state listed rare, threatened or endangered Geadephaga occur within the study site. Currently, there are 64 Geadephaga, all carabid species, listed as rare, threatened or endangered in Virginia, the vast majority of these occurring in the genera *Pseudanophthalmus* (including 13 unnamed species) or *Cicindela* (Roble, 2013).

STUDY SITE

The study site includes lands managed by the National Park Service as units of the George Washington Memorial Parkway (GWMP) in Virginia (Fairfax and Arlington counties and the City of Alexandria) and the District of Columbia. Park sites that received the greatest inventory effort included: in Fairfax County, Claude Moore Colonial Farm, Collingwood Picnic Area, Dyke Marsh Wildlife Refuge, Fort Hunt Park, Fort Marcy, Great Falls Park, Little Hunting Creek, Riverside Park, and Turkey Run Park; in Arlington County, Arlington Woods (at Arlington House), the Potomac Heritage Trail, and Roaches Run Waterfowl Sanctuary; in the City of Alexandria, Daingerfield Island and Jones Point Park; and in the District of Columbia, Columbia Island and Theodore Roosevelt Island. This area covers approximately 1,615 ha. Great Falls and Turkey Run parks and some of the Potomac Heritage Trail fall within the Piedmont physiographic province while all other collection sites are on the Coastal Plain. Most sites are situated along the shore of the Potomac River, and Great Falls and Turkey Run Parks and the Potomac Heritage Trail border the Potomac River Gorge, an area known for high species richness of plants and animals (Cohn, 2004). Most of the study sites are dominated by maturing, second growth, primarily upland, deciduous woodlands. More open habitats can be found in moist, narrow, herbaceous dominated bands along the shore of Potomac River, in the swamp and marsh habitats at Dyke Marsh, and in areas with managed turf grass and scattered large trees, such as Collingwood Picnic Area and Fort Hunt Park. The vascular flora of the GWMP is diverse, with more than 1,313 taxa recorded, 1,020 from Great Falls Park alone (Steury et al., 2008; Steury, 2011).

MATERIALS AND METHODS

The number of geadephagan species documented from GWMP has grown since the first inventory targeting these families occurred in Great Falls and Turkey Run parks on three days in 2006 during the Potomac Gorge Bioblitz, which documented 30 species (Evans, 2008). The current list of 184 species is the result of approximately nine years (2004-summer 2013)

of sporadic survey effort targeting arthropods using eight collecting techniques as follows: yellow, blue, and white pan traps in Great Falls Park (two years); Malaise traps set at Dyke Marsh (five years), and Great Falls and Turkey Run parks (three years); pit-fall traps set at Dyke Marsh (five years) and at Little Hunting Creek and Great Falls and Turkey Run Parks (three years); Lindgren funnel and black-light (UV) bucket traps set at Dyke Marsh, Great Falls Park, Little Hunting Creek, and Turkey Run Park (two years); black-light shown on sheets at Great Falls and Turkey Run parks (three years); leaf litter samples from Arlington Woods, Dyke Marsh, Fort Marcy, Great Falls Park, Roaches Run Waterfowl Sanctuary, and Turkey Run Park, processed in Berlese funnels (two years); beating sheets used during the Potomac Gorge Bioblitz and sporadically at other times over two years; and collecting by hand at all sites, intensively for two years. Specimens were pinned and labeled and deposited in the collections maintained at the George Washington Memorial Parkway, Turkey Run Park Headquarters in McLean, Virginia. To determine new Virginia records we reviewed the literature associated with the citations listed in the introduction. To determine carabid records new for the Potomac River Gorge we reviewed publications by Stork (1984), Erwin (1981), Steiner & Erwin (2007), Brown (2008), Evans (2008), and Bousquet & Messer (2010). Habitat associations and notes on life history were made for specimens collected by hand or found in leaf litter samples filtered through Berlese funnels.

RESULTS

A total of 184 geadephagan species (183 carabids and one rhysodid) in 70 genera and 30 tribes was documented from GWMP. Seven species, *Elaphropus quadrisignatus* (Duftschmid), *Harpalus rubripes* (Duftschmid), *Microlestes pusio* (LeConte), *Platynus opaculus* LeConte, *Pterostichus permundus* (Say), *P. sculptus* LeConte, and *Scarites vicinus* Chaudoir, are reported here as new records for Virginia. A female, tentatively identified as *Loxandrus circulus* Allen, may represent an eighth species new to the Commonwealth. Seven carabids, *Anisodactylus dulcicollis* (LaFerté-Sénectère), *Elaphropus anceps* (LeConte), *E. saturatus* (Casey), *Oodes americanus* Dejean, *P. permundus*, *S. vicinus*, and *Tachys potomaca* (Erwin), are new to the District of Columbia. These new records increase the number of carabid beetles known from Virginia to 543 taxa (however the record for *L. circulus* needs confirmation), and the number known from the District of Columbia increases to 350 taxa. With a total of 543 taxa, Virginia surpasses the total reported for North Carolina in Bousquet (2012), giving Virginia the fourth most species-rich geadephagan fauna of all political regions in the United States and Canada. One species, *Phloeoxena signata* (Dejean), is listed as rare (S3) in Virginia (Roble, 2013). Eight species are adventive to North America.

The 184 geadephagan beetles collected from GWMP surpasses the number of species listed for some of the most studied sites in Virginia and Maryland. These sites include Quantico Marine Corps Base in adjacent Prince William and Stafford counties, Virginia, with 114 species (Hoffman, 2010), and Eastern Neck National Wildlife Refuge in Kent County, Maryland, with 80 species (Staines & Staines, 2011). Carabid inventories between 1970 and 1984 on Plummers Island in the Potomac River Gorge of Montgomery County, Maryland, yielded 117 species (Erwin, 1981; Stork, 1984). However, 214 carabid beetle species have been collected on Plummers Island over the last 100 years based on literature reviews and historical collections at the Smithsonian Institution, National Museum of Natural History (Brown, 2008; Erwin, 1981). Forty-nine species documented from GWMP are not known to occur on Plummers Island. Of these, 37 were documented for the first time along the Potomac River Gorge within 6 km north or south of Plummers Island. These species, plus three others (*Acupalpus indistinctus* Dejean, *Agonum punctiforme* [Say], and *Amphasia sericea* [Harris]) reported from the Potomac River Gorge by Evans (2008), and the addition of *Agonoleptus thoracicus* (Casey) by Bousquet & Messer (2010), bring the total number of carabids documented from the Potomac River Gorge to 255 species. The report of *Scaphinotus viduus* (Dejean) from the Potomac River Gorge by Evans (2008) is based on a misidentified specimen of *S. unicolor* (Fabricius). The records for *Trichotichnus dichrous* (Dejean) in Evans (2008), a species not seen in the Potomac River Gorge since 1932, are based on misidentified specimens of *Selenophorus opalinus* (LeConte).

Anderson et al. (1995) suggested that the high number of carabids found on Plummers Island (many represented by just a few specimens) may be the result of random flight dispersal or downstream transport by high water, but the rediscovery of 40 of these species during this study, or by Evans (2008), suggests that most of them are rare, persistent residents of the Potomac River Gorge. Despite over nine years of sporadic survey effort using eight collecting techniques, 46 species (25%) documented by this study are represented by a single specimen. The GWMP sites with the highest species richness were Great Falls Park with 118 (26 unique to this site), Turkey Run Park with

110 (23), and Dyke Marsh Wildlife Refuge with 55 (12). Hand picking proved to be the most successful method of capturing carabid beetles during this study, yielding 134 species, including 50 captured only using this method. Comparable figures for other sampling methods were: Malaise traps, 83 (19 unique); Berlese funnels, 37 (3); black lights, 35 species (7); and pit-fall traps 31 (6). The capture of 83 species in Malaise traps suggests that these species may be strong fliers with substantial dispersal power, although these traps also captured a few species such as *Myas coracinus* (Say) and *Pterostichus tristis* (Dejean) that are not known to have flight abilities (Larochelle & Larivière, 2003). The 68 species captured only in pit-fall traps or by hand picking may indicate that these species fly less readily or not at all, although a number of infrequently collected species (*Agonum striatopunctatum* Dejean, *Anisodactylus rusticus* (Say), *Apristus latens* (LeConte), *Bembidion americanum* Dejean, *B. castor* Lindroth, *B. lacunarium* (Zimmermann), *B. levigatum* Say, *B. rolandi* Fall, *Brachinus fumans* (Fabricius), *Bradycellus atrimedeus* (Say), *Chlaenius cordicollis* Kirby, *C. impunctifrons* Say, *C. laticollis* Say, *C. sericeus* (Forster), *Cicindela tranquebarica tranquebarica* Herbst, *C. repanda repanda* Dejean, etc.), *Dyschirius sphaericollis* (Say), *Elaphrus californicus* Mannerheim, and a more common one (*Bembidion honestum* Say), that are noted as strong fliers (Larochelle & Larivière, 2003) also were captured only using these two methods. Species collected between mid-November and mid-March probably overwintered as adults, although many of these same species may overwinter as larvae as well.

Most native carabid beetle species recorded from GWMP have wide north-south ranges within their eastern United States distributions. However, a few species such as *Cyclotrachelus furtivus* (LeConte), *Microlestes pusio* (LeConte), *Scarites vicinus* Chaudoir, and *Tachys potomaca* (Erwin) are less widely distributed and restricted to, or rare within, the Mid-Atlantic area. The ten most commonly collected carabids during this study, in decreasing order of abundance, were *Stenolophus ochropezus* (Say), *Agonum punctiforme*, *Bembidion affine* Say, *Pterostichus sculptus* LeConte, *Bembidion fugax* (LeConte), *Elaphropus saturatus* (Casey), *Cicindela sexguttata* Fabricius, *Chlaenius aestivus* Say, *Agonoleptus conjunctus* (Say), and *Platynus tenuicollis* (LeConte) (see list of species for number of each species captured). The most common genera were *Bembidion* (18 species), *Agonum* and *Anisodactylus* (9), *Chlaenius* and *Elaphropus* (8), *Lebia* and *Pterostichus* (7), and *Amara* (6).

Surprising omissions from this inventory based on their abundance and recent (circa 1975) presence on Plummers Island include the following 15 species: *Agonum rigidulum* (Casey), *A. tenue* (LeConte), *Badister notatus* Haldeman, *Calathus gregarius* (Say), *Cyclotrachelus approximatus* (LeConte), *Dicaelus ambiguus* LaFerté-Sénectère, *D. politus* Dejean, *Dromius piceus* Dejean, *Dyschirius pilosus* LeConte, *Elaphropus incurvus* (Say), *Harpalus faunus* Say, *Olisthopus micans* LeConte, *Pterostichus caudicalis* (Say), *Stenolophus comma* (Fabricius), and *Trichotichnus vulpeculus* (Say). The absence of these species after nine years of survey effort is even more surprising considering that 73.3% are macropterous and most are strong fliers.

LIST OF SPECIES

Taxa are listed by family and tribe following the nomenclature and taxonomic order used by Bousquet (2012). Seven carabid species new to the Commonwealth of Virginia, and one potentially new (*Loxandrus* nr. *circulus* Allen), are marked by a dagger (†). Seven species new to the District of Columbia are marked with a double dagger (‡). Thirty-seven carabid species found along the Potomac River Gorge that were previously unrecorded from the Gorge are marked with an asterisk (*). Forty-nine species found during this study that have not been found on Plummers Island are marked with an exclamation point (!). Eight species non-native to North America are signified with a diamond (◊). The number of specimens in the collection is indicated in parentheses after each taxon. Sites where specimens were collected are given for the District of Columbia: Columbia Island (CI), Theodore Roosevelt Island (RI); Arlington County, Virginia: Arlington Woods (AW), Potomac Heritage Trail (PH), Roaches Run Waterfowl Sanctuary (RR); City of Alexandria, Virginia: Daingerfield Island (DI), Jones Point Park (JP); and Fairfax County, Virginia: Claude Moore Colonial Farm (CM), Collingwood Picnic Area (CP), Dyke Marsh Wildlife Preserve (DM), Fort Hunt Park (FH), Fort Marcy (FM), Great Falls Park (GF), Little Hunting Creek (LH), Riverside Park (RP) and Turkey Run Park (TR). Collection methods are listed using the following abbreviations: Berlese funnel (bf); beating sheet (bs); black light (UV) traps or sheets (bl); hand picking, including the use of coverboards and splashing soil with water (hp); Lindgren funnel (lf); Malaise trap (mt); pan trap (pt); and pit-fall trap (pf). The periods of adult activity are given based on dates when live collected taxa have been documented in the park. Dates separated by a hyphen indicate that the taxon was documented on at least one day during each month within this continuum of months, whereas dates

separated by a comma represent individual observation dates. For traps set over multiple weeks, the first day of the set is used as the earliest date and the last day of the set as the latest date. Species found during this survey that have not been collected from the Potomac River Gorge within the last 70 years are indicated by the abbreviation "PRG" followed by the year of the last known collection. The habitats of taxa collected by hand or in leaf litter samples are described along with other notes on the species' biology. References to "woods" or "woodlands" mean upland deciduous forests unless indicated otherwise.

RHYSODIDAE

CLINIDIINI

Clinidium sculptile (Newman)–(10); FM, GF, TR; bf, hp; 14 Apr - 16 May; PRG 1917; on tree trunk at night; under bark; leaf litter in woods.

CARABIDAE

NEBRIINI

Nebria lacustris Casey–(7); GF, TR; bl, hp; 15 Sep-15 Oct; creek mouth, gravelly, silt and cobble shore; rocky, non-tidal river shore with sand and silt. Gregarious, usually in groups of three to five, or sometimes solitary, sometimes with *N. pallipes*.

Nebria pallipes Say–(5); TR; hp; 6 May, 15-26 Sep; rocky, non-tidal river shore with sand and silt; creek mouth with gravel, silt, and cobble; creek mouth under rock on silty sand. A subteneral specimen was captured on 6 May 2006.

NOTIOPHILINI

Notiophilus aeneus (Herbst)–(5); GF; pf; 11 Apr-29 Jun.

Notiophilus novemstriatus LeConte–(2); GF, TR; hp; 20 May, 25 Sep; under coverboard at edge of woods; in gravelly soil at edge of road.

Notiophilus semistriatus Say–(1); GF; bs; 24 Jun; PRG 1918; captured while presumably climbing vegetation.

CYCHRINI

Sphaeroderus stenostomus lecontei Dejean–(12); AW, FM, GF, TR; bf, hp, pf; 19 Mar-15 Jul; under log in woods; leaf litter in woods.

Scaphinotus unicolor (Fabricius)–(4); GF; hp, pf; 11-27 Apr, 24 Jun, 21 Sep-13 Oct; PRG 1943; woods in leaf litter. This large and brilliantly violaceous variant of *S. unicolor* known in the Potomac River region was previously assigned to subspecies *S. unicolor shoemakeri* Leng, but that name was recently synonymized with nominate *S. unicolor*.

CARABINI

Calosoma scrutator (Fabricius)–(1); FH; hp; 10 Aug; dead in pavilion.

Carabus vinctus (Weber)–(3); GF; hp; 17 Apr, 24 Aug; PRG 1914; under log at swamp edge; on dirt road.

CICINDELINI

Cicindela punctulata punctulata Olivier–(1); TR; hp; 5 Jul; PRG 1918; found dead in parking lot.

!*Cicindela tranquebarica tranquebarica* Herbst–(1); FH; hp; 19 Sep; edge of turf grass and dirt infield of baseball diamond.

Cicindela sexguttata Fabricius–(32); GF, LH, TR; hp, pf, mt; 10 Apr-30 Jul; on trail in woods.

Cicindela repanda repanda Dejean–(5); GF, TR; hp; 22-23 May, 11-26 Sep; sand bank along river.

ELAPHRINI

Elaphrus californicus Mannerheim–(3); TR; hp; 30 May; non-tidal river channel shore on silty sand.

Elaphrus ruscarius Say–(2); DM, TR; hp, mt; 19 Apr-30 May; non-tidal river channel shore on silty sand.

OMOPHRONINI

Omophron americanum Dejean–(4); TR; hp; 23-30 May, 29 Aug; non-tidal river channel shore on silty sand.

SCARITINI

†‡*!*Scarites vicinus* Chaudoir–(6); GF, RI, TR; bl, hp, pf; 27 Apr-25 Jun, 30 Aug-6 Sep; sandy woodland under log; creek mouth with cobble, silt and driftwood; under log in dry woods. A teneral specimen was captured on 30 August 2012 in Great Falls Park. This species has a generally Midwestern distribution along the Mississippi River drainages reaching eastward to Ohio, Kentucky, Tennessee, and now Virginia. These records are the first for the East Coast of the United

States. The nearly identical *S. quadriceps* Chaudoir has been reported from adjacent Maryland and North Carolina, but not Virginia. Specimens from GWMP demonstrate relatively equal ratios of metasternum length to metacoxa length (measured through the same maximum longitudinal line) as is similarly observed in typical *S. vicinus* from the Midwestern United States. In typical *S. quadriceps*, the metasternum is visibly longer compared to the metacoxa.

Scarites subterraneus Fabricius–(7); CP, RI, TR; hp; 13 May-23 Jun, 29 Aug-11 Sep; under log in woods; creek mouth with cobble, silt, and driftwood; woodland edge under coverboard; sandy woods under log; in building.

CLIVININI

Clivina dentipes Dejean–(13); GF, PH, TR; bl, hp; 15 May-25 Sep; rocky non-tidal shore with sand and silt; non-tidal shore with sand and cobble; tidal shore on silty sand under river drift; woodland edge under coverboard.

!*Clivina pallida* Say–(1); AW; bf; 14 May; leaf litter in woods.

Clivina americana Dejean–(7); GF; bl, hp, mt; 17 Apr-23 Jun, 30 Aug; riverside sand and cobble; under streamside rock in woods.

Paraclivina bipustulata (Fabricius)–(8); AW, GF; bf, bl; 14 May-23 Jun; leaf litter in woods.

Paraclivina ferrea (LeConte)–(1); RI; hp; 15 May; PRG 1903; sandy tidal beach under driftwood.

*!*Schizogenius amphibius* (Haldeman)–(6); DM, JP, RI; hp; 2 May, 20 Jun, 6 Sep; sandy tidal shore under cobble. The Potomac River Gorge specimen was found at the mouth of the gorge on the northern shore of Theodore Roosevelt Island.

Schizogenius lineolatus (Say)–(18); DM, GF, TR; hp; 15-30 May, 30 Aug-18 Sep; rocky non-tidal beach with sand and silt; river shore with cobble and driftwood; sandy tidal beach with cobble; sandy non-tidal beach with silt cakes and sparse vegetation.

!*Ardistomis obliquata* Putzeys–(8); DM; bf, hp, mt; 15 Apr-6 Jun; gravelly tidal shore on log in patch of *Schoenoplectus pungens* (Vahl) Palla.; in leaf litter near water.

Semiardistomis viridis (Say)–(25), DM, GF, PH, RI; bf, hp, mt; 15 May-21 Oct; rocky non-tidal shore with silt and gravel; sandy tidal shore with cobble; leaf litter near water.

DYSCHIRIINI

Dyschirius haemorrhoidalis (Dejean)–(5); DM, GF, TR; bl, hp; 30 May-30 Jul, 9 Sep; river shore on sand and clay; non-tidal river channel on silty sand.

Dyschirius sphaericollis (Say)–(4); GF, TR; hp; 20-30 May; sandy non-tidal river shore; non-tidal river channel shore on silty sand.

BEMBIDIINI

Bembidion nigrum Say–(2); TR; hp; 29 Aug-9 Sep; PRG 1906; creek mouth on sand and clay.

Bembidion inaequale Say–(7); GF; TR; hp, mt; 10 Apr-20 May, 29 Aug; non-tidal shore with sand, mud and sparse vegetation; creek mouth on clay bank.

Bembidion americanum Dejean–(1); GF; hp; 9 Sep; PRG 1906; non-tidal river shore with cobble and drift wood.

*!*Bembidion antiquum* Dejean–(7); DM, RI, TR; hp, mt; 12 Apr-22 May, 25 Sep; non-tidal shore with cobble, silt and driftwood; tidal sandy beach under driftwood; rocky shore with sand and silt. This species and the next two are members of the subgenus *Pseudoperyphus*, a diagnostically challenging group when not comparing male genitalia (Maddison, 2008). It is possible that the record of *B. chalceum* Dejean from the Potomac River Gorge reported by Stork (1984) and cited by Brown (2008) was actually *B. antiquum*, which at that time was thought by some authors to be a synonym of *B. chalceum*. Our identification of *B. antiquum* is based on the combination of geographic location, body length > 6.0 mm, appendages partly pale, pronotum moderately convex with lateral borders well rounded and sinuate to base, elytra with posterior punctures non-foveate, intervals flat, weakly impressed elytral striae which tend to vanish apically, and elytral microsculpture mesh with a tendency to be stretched transversely. Dissected genitalia of two males each demonstrated the characteristic widely sinuate flagellum-like structure located inside the median lobe. This species bears close resemblance to the widespread *B. chalceum*, which was reported from the Potomac River region by Stork (1984) and Maddison (2008). However, no specimens from this inventory fit typical *B. chalceum* which is

distinguished by its smaller size (< 6.0 mm long), a pronotum that is quite convex with deep basolateral depressions, and elytra with intervals distinctly convex and with striae extended deeply to apex.

Bembidion honestum Say–(11); GF, TR; hp; 16-22 May, 18-26 Sep; non-tidal rocky beach with sand and silt; cobble, silt and driftwood at creek mouth; silty sand under rock at creek mouth. Identification of *B. honestum* is based here on the combination of geographic location, body length of 5.5 - 6.0 mm, pronotum being relatively broad and flat with basolateral depressions that are very shallow, pronotal luster relatively dull, elytra with posterior punctures more or less foveate, elytral striae distinctly engraved to apex, and elytral microsculpture mesh nearly isodiametric.

!*Bembidion rothfelsi* Maddison–(4); DM, RP; hp; 3-15 May; tidal sandy beach; tidal sandy cobble beach with *Schoenoplectus pungens*; tidal shore with cobble and sand. Identification of *B. rothfelsi* is based on the combination of geographic location and, in comparison to otherwise similar *B. antiquum*, the pronotum is narrower, the pronotal outline is less rounded, the reflexed pronotal margin is narrower, the elytra intervals are not as flat, and the striae, although rather thin, are less diminished apically. Consistent with the descriptions in Maddison (2008), our one male specimen was observed to have its intragenitalic flagellum less bent, therefore less sinuate as compared to that of *B. antiquum*.

*!◊*Bembidion tetracolum tetracolum* Say–(1); PH; hp; 11 Sep; sandy beach under vegetation washed ashore.

Bembidion lacunarium (Zimmermann)–(1); TR; hp; 6 May; PRG 1905; creek edge.

Bembidion affine Say–(37); CP, DM, GF, RI, TR; bl, hp, mt; 31 Jan, 9 May-24 Oct; non-tidal shore with cobble, silt, and driftwood; non-tidal shore with sand and clay; tidal shore with gravel and cobble. A sub-teneral specimen was captured on 29 August 2013.

Bembidion impotens Casey–(10); DM, GF, PH, RI, TR; hp, mt; 9 Aug-11 Oct; non-tidal river shore with cobble and driftwood; sandy tidal shore; creek mouth with sand and clay.

Bembidion castor Lindroth–(8); GF, PH, TR; hp; 20 May, 29 Aug-25 Sep; moist sandy shore under vegetation; non-tidal river shore with cobble and driftwood; non-tidal rocky shore with sand and silt; non-tidal shore with sand, mud, and sparse vegetation.

Bembidion patruele Dejean–(3); DM, TR; hp, mt; 6-20 Jun, 9-26 Sep; creek mouth with sand and clay; silty sandy shore under rock.

Bembidion rapidum (LeConte)–(6); DM, TR; mt; 8-23 May, 16 Jul-11 Oct.

*!*Bembidion frontale* (LeConte)–(1); TR; mt; 1-22 May.

Bembidion levigatum Say–(1); PH; hp; 17 June; tidal shore with silty sand and clay.

Bembidion variegatum Say–(6); GF, TR; hp; 20-23 May; non-tidal shore with sand, mud and sparse vegetation; muddy shore of river channel.

Bembidion fugax (LeConte)–(34); GF, RI, TR; hp, mt; 10 Apr-23 May, 9-18 Sep; rocky shore with sand and silt; non-tidal shore with cobble, sand, and driftwood; non-tidal river shore with sand and clay; sandy tidal beach under driftwood.

*!*Bembidion rolandi* Fall–(5); GF; hp; 16 May, 18 Sep; non-tidal beach under rock on gravelly, silty, sand; creek mouth with cobble and driftwood.

Mioptachys flavicauda (Say)–(24); AW, DM, GF, TR; bf, bs, mt; 14 Apr-23 May, 27-29 Aug; riverside prairie; leaf litter in woods. Considering the relatively large number of captures of this minute (1.5-1.8 mm) beetle, it is probably very common in the study area.

Tachyta inornata (Say)–(11); AW, GF, TR; bf, hp, mt; 10-30 Apr, 15 Dec; PRG 1905; under loose bark of fallen *Liriodendron tulipifera* L.; leaf litter in woods.

‡*!*Elaphropus anceps* (LeConte)–(12); AW, GF, JP, RI, TR; bf, hp; 15 Apr-30 May, 29 Aug-6 Sep; tidal shore on pure sand under log; tidal shore under rock on sand; non-tidal shore on silty sand; leaf litter in woods. This species has been documented from Virginia and Maryland, along with 32 other states, so it was to be expected in the District of Columbia.

!*Elaphropus capax* (LeConte)–(1); RP; hp; 9 May; sandy tidal beach under cobble.

‡*Elaphropus saturatus* (Casey)–(34); DM, JP, PH, RI, RP, TR; hp, mt; 12 Apr-20 Jun, 30 Aug-19 Sep; tidal shore on gravel bar under rock; tidal shore under cobble; creek mouth with cobble, silt, and driftwood;

tidal, sandy beach with cobble and *Schoenoplectus pungens*; tidal shore on silty sand under driftwood; rocky non-tidal shore with sand and silt. On 9 May 2012, at least 14 *E. saturatus* were found under a 30 x 30 cm rock on a cobble bar at Jones Point Park approximately 10 m from the tidal shore. As the tide ebbed, the cobble bar and rock, submerged at high tide, became exposed but were still entirely surrounded by water. The *E. saturatus* found under the rock on this cobble bar must have survived tidal submersion for at least six hours. Larochelle & Larivière (2003) list the habitats of this species as banks of rivers and brooks, drier zone of lake shores, borders of marshes, cultivated fields, and open ground with moderately moist substrates and sparse vegetation, but make no mention of the species' adaptation to long periods of submersion. This species was first documented from Virginia by Hoffman (2010). See *E. vivax* for a discussion on resolving the occasional difficulty in distinguishing that species from *E. saturatus* on the basis of coloration.

Elaphropus tripunctatus (Say)–(15); GF, PH, RI, TR; hp, mt; 1-22 May, 9-19 Sep; PRG 1907; non-tidal rocky beach with sand and silt; river shore with cobble and driftwood; sandy tidal beach under driftwood.

Elaphropus vernicatus (Casey)–(2); PH; hp; 17 Apr, 17 Jun; sandy, silty, tidal shore under sticks.

Elaphropus vivax (LeConte)–(15); GF, TR; hp; 22 May-26 Jun, 29 Aug-25 Sep; non-tidal sandy river shore; non-tidal river shore on sand and clay; muddy shore under leaf litter; non-tidal shore with cobble, silt, and driftwood. Typical *E. vivax* is uniformly yellowish-red and therefore readily distinguished in most cases from darker reddish-brown *E. saturatus* by noting the coloration of their forebodies, antennae, and palps (Bousquet, 2010). However, some individuals of *E. saturatus* from GWMP had those body parts sufficiently lighter in color so as to cause confusion with otherwise similar *E. vivax*. A more reliable character for distinguishing these species is the degree of surface microsculpture (mesh) on the posterior half of the frons and laterally on the subapical abdominal sterna. Unlike *E. saturatus*, in which the mesh is distinct, in *E. vivax* the mesh is obscure to absent on the posterior frons and on the subapical sterna, thereby rendering those areas very shiny under microscopy. A teneral and two sub-teneral specimens were captured on 29 August 2013.

Elaphropus xanthopus (Dejean)–(19); AW, DI, DM, FH, GF, JP, PH, RI, TR; bf, bl, hp, mt, pt; 10 Apr-26 Sep; moist upland depression under log; rocky non-tidal shore with gravel, silt, and sand; creek mouth with cobble, silt, and drift wood; riverside prairie; under thin soil over concrete, leaf litter in woods. Surprisingly, this common beetle was not attributed to the Virginia fauna until Hoffman et al. (2006) noted it. The first records for Fairfax County were documented by Evans (2008). We report the first records for Arlington County and the City of Alexandria. This is the only *Elaphropus* species that was found at sites away from river shores, with the exception of two specimens of *E. anceps*. It is reported from Plummers Island (Brown, 2008) under the synonym *E. levipes* (Casey).

†*!◊*Elaphropus quadrisignatus* (Duftschmid)–(1); PH; hp; 17 Jun; tidal shore on silty sand under debris. This is the first record for Virginia and only the second known capture in the New World. The first capture occurred on 23 June 2010 at a UV light in Burlington County, New Jersey. The corresponding habitus images and collection data were posted on the website BugGuide.net by collector Tim Moyer. That specimen was examined, determined, and retained by P.W. Messer, who subsequently received species corroboration from authority Terry Erwin based on his recognition of the distinct habitus images (pers. comm. 27 June 2012). This species is not listed in the North American catalogue by Bousquet (2012). According to Löbl & Smetana (2003), *E. quadrisignatus* has been documented from Europe, west to Portugal and the United Kingdom, north to Poland, east to Turkey and Cyprus, south to Macedonia and Italy and in northern Africa (Algeria and Morocco).

Polyderis laeva (Say)–(7); DM, GF, PH, RR; bf; 15 Apr, 19-21 Oct; PRG 1923; leaf litter in woods. This is the smallest carabid beetle collected at GWMP, measuring only 1.2 to 1.5 mm.

Tachys oblitus Casey–(21); AW, DM, GF, RP; bf, hp, mt; 11 May-30 Aug; 19-21 Oct; leaf litter near water; leaf litter in woods; non-tidal river shore with sand and cobble; sandy tidal shore under driftwood. The three specimens from Great Falls Park represent the second time this species has been found in the Potomac River Gorge, the first being from Plummers Island in 1960. These are the first records for Fairfax and Arlington counties based on the Virginia range documented by Roble & Hoffman (2012).

‡*Tachys potomaca* (Erwin)–(26); DM, GF, PH, RI, TR; bf, hp; 15 Apr-15 May; 6 Sep-21 Oct; leaf litter near water; leaf litter in woods; sandy tidal beach under log; tidal beach on sand and silt under moist leaf litter.

Described as a new species in 1981, the type locality for this brachypterous carabid is in the Potomac River Gorge. Its known range is restricted to five Mid-Atlantic states between Massachusetts and North Carolina with an inland station reported from Ohio. The District of Columbia is added here to the known range of the species.

Tachys proximus (Say)–(1); DM; mt; 20 Jun-2 Jul.

Tachys scitulus LeConte–(18); DM, GF, PH, TR; bf, bl, hp, mt; 15 Apr-26 Sep; tidal shore on silty sand under driftwood; muddy non-tidal shore under leaf litter; creek mouth with cobble silt and driftwood; leaf litter near water. This wide ranging species was first recorded for Virginia by Hoffman et al. (2006). Evans (2008) documented the first record for Fairfax County and the Dyke Marsh specimens represent the second Coastal Plain records from Virginia (Hoffman, 2010). We add Arlington County to its known distribution in Virginia. A teneral specimen was captured in Turkey Run Park on 25 September 2012.

PATROBINI

Patrobus longicornis (Say)–(5); JP, PH, TR; hp; 9 May-26 Jun, 11-26 Sep; tidal shore, silty sand under driftwood; creek mouth, silty sand under rock; woods inside rotting log.

BRACHININI

Brachinus fumans (Fabricius)–(1); TR; hp; 9 Sep; PRG 1908; under coverboard at edge of woods.

ABACETINI

*!*Loxandrus brevicollis* (LeConte)–(2); GF; hp, mt; 24 Apr-18 Jun; in moist leaf litter at edge of vernal pool.

†*Loxandrus* nr. *circulus* Allen–(1♀); GF; mt; 1-20 May. Geographically, *L. circulus* is the most probable of the five species belonging to a subset of the *erraticus* group that ends in couplet #74 for females in the taxonomic key by Allen (1972). Ranges for the other four species (*L. cincinnati* Casey, *L. minor* (Chaudoir), *L. nitidulus* (LeConte), *L. robustus* Allen) are relatively far removed from Virginia. Although *L. circulus* has not been previously recorded from Virginia, it is known from adjacent Plummers Island, Maryland. Globally, *L. circulus* is known only from a few localities in Maryland, the District of Columbia, northern Ohio, Mississippi, and Alabama (Bousquet, 2012).

*!*Loxandrus vulneratus* Casey–(3); CM, GF; bl, hp; 11 Mar, 25 May; under rock near vernal pool.

*!*Loxandrus rectus* (Say)–(1); GF; bl; 12 Jul.

PTEROSTICHINI

Poecilus lucublandus (Say)–(15); CM, CP, FH, GF; hp, pf, mt; 8 Apr-29 Jun, 30 Aug-11 Nov; swamp under log; woodland edge under log; turf grass; parking lot; in building.

Gastrellarius honestus (Say)–(2); TR; hp; 14 Apr, 15 Dec; PRG 1922; under bark of fallen *Fagus grandifolia* Ehrhart.

Myas coracinus (Say)–(8); GF, LH, TR; hp, pf, mt; 6 Jun-17 Jul, 23 Sep-14 Nov; PRG 1923; rich woods under log; in building.

Pterostichus trinarius (Casey)–(18); GF, TR; hp, pf; 11 Apr-7 Jul, 23 Sep-13 Oct; under bark; on trail in woods.

Pterostichus coracinus (Newman)–(2); GF, TR; pf; 16-30 Jun, 23 Sep-13 Oct; PRG 1919. The report of this species by Evans (2008) from the Gorge is based on a misidentified *P. stygicus*.

Pterostichus stygicus (Say)–(19); FM, GF, LH, PH, TR; bf, hp; 16 May-23 Jun, 29 Aug-25 Sep; tidal shore, silty sand under driftwood; turf grass under board near woods; under coverboard at edge of woods; rocky non-tidal shore with sand and silt; swamp under log; dry vernal pool under log; rich woods under log; leaf litter in woods.

*!*Pterostichus atratus* (Newman)–(3); GF; pf; 23 Sep-20 Oct.

†‡*!*Pterostichus permundus* (Say)–(7); GF, PH, RI, TR; hp, pf; 30 Aug-23 Oct; tidal shore under driftwood on sand, silt, and wet leaf litter; tidal shore under log on pure sand; turf grass under board near woods; in building. The known range for *P. permundus* is from southern Ontario and northern Michigan to southeastern South Dakota, northeastern Texas, and northeastern Florida (Bousquet, 2012).

†*!*Pterostichus sculptus* LeConte–(36); CP, DM, FH, GF, JP; bf, hp; 9 May-2 Jun, 19 Sep-11 Nov; under rock at edge of woods; under log in turf grass; tidal shore under driftwood; leaf litter near water; crossing stone road; under leaf litter on parking lot curb; in building. The documented range for *P. sculptus* is from

New York to Iowa, south to Arkansas, Alabama, Georgia and South Carolina (Bousquet, 2012). Despite its status as a new state record, this is the most common large carabid found in the study area. The species was listed as nocturnal by Larochelle & Larivière (2003), but one specimen at Dyke Marsh was found crossing a stone road at midday. In September, a group of nine *P. sculptus* was found under a rock measuring 30 x 35 cm. Adult lengths for this species have been listed as 15 - 17 mm (Downie & Arnett, 1996; Ciegler, 2000), but five smaller specimens (12.5 to 13.5 mm) were found in the study area. A subteneral specimen was found in Great Falls Park on 20 May, 2013.

Pterostichus tristis (Dejean)–(3); GF, TR; hp, mt, pf; 19 Apr-21 May, 7-16 Jul; in building.

Cyclotrachelus sigillatus (Say)–(7); TR; hp, pf; 2 Jun-29 Aug; PRG 1909; under coverboard at edge of woods; under log in rich woods; in building.

*!*Cyclotrachelus furtivus* (LeConte)–(12); FH, GF, TR; hp, pf; 2 Jun-29 Aug; under coverboard at edge of woods; rich woods under log; in building. The known range of this large, brachypterous carabid extends from central Virginia north to New Jersey and west to West Virginia.

ZABRINI

*!*Amara pennsylvanica* Hayward–(1); GF; hp; 1 May; near pond.

Amara exarata Dejean–(1); TR; hp; 13 Sep; PRG 1919; woodland edge under coverboard.

Amara impuncticollis (Say)–(6); CM, GF, TR; bf, hp, mt; 7 Mar-22 May; under rock in woods, under bark pile in woods; in leaf litter.

◊*Amara aenea* (DeGeer)–(10); AH, CP, DM, GF, PH, TR; bf, hp, pf; 20 Feb-24 Jun; on stone road; in turf grass at edge of parking lot; in leaf litter.

◊*Amara anthobia* Villa & Villa–(9); CP, DI, FM, JP, TR; hp; 7 Mar-11 Jun, 10 Nov; turf grass at edge of parking lot; in parking lot; moist depression under log, under rock in woods, on sidewalk. On the East Coast, this introduced European beetle has been recorded only in New York, Maryland, and Virginia.

◊*Amara familiaris* (Duftschmid)–(5); DM, GF, JP, PH; hp, mt; 8-28 Apr, 20 Jun-2 Jul; on sidewalk; river shore on sand and silt under sticks; under rock at woodland edge.

OODINI

!*Lachnocrepis parallela* (Say)–(3); DM; mt; 19-28 Apr, 29 Aug-10 Oct.

Oodes amaroides Dejean–(3); DM, GF, TR; bf, bl, hp; 15 Apr-25 May; muddy shore of river channel; leaf litter near water.

‡*!*Oodes americanus* Dejean–(2); RI; hp; 15 May; under driftwood at upper edge of sand beach. Based on the range given for this species in Bousquet (2012), this capture likely represents the northernmost known record. This species is tentatively separated externally from very similar *O. fluvialis* by its proportionately broader pronotal base and by its elytrial striae possibly more finely and distantly punctate. Reliable species separation, as used to determine this record, requires examination of the dissected aedeagus as described by Bousquet (1996).

*!*Oodes brevis* Lindroth–(4); FM, GF, LH; bf, hp, mt, pf; 10 Apr-16 May; near pond; leaf litter in woods.

*!*Oodes fluvialis* LeConte–(1); DM; hp; 22 Mar; under log in swamp.

Stenocrepis cuprea (Chaudoir)–(4); GF, TR; bl, hp; 7 Jul, 9 Sep.

CHLAENIINI

*!*Chlaenius amoenus* Dejean–(5); FM, GF, TR; bf, pf; 15 Apr-7 Jul.

Chlaenius emarginatus Say–(1); DM; mt; 18-23 Jul.

Chlaenius aestivus Say–(31); DM, GF, JP, TR; bf, hp, pf, mt; 11 Apr-26 Jul, 25 Sep; under loose pine bark; under coverboard at edge of woods; tidal shore under drift wood; muddy non-tidal shore under leaf litter; rocky non-tidal shore under rock on muddy sand; leaf litter near water. This species was observed to be gregarious at dry upland sites but solitary on moist river banks.

Chlaenius laticollis Say–(4); TR; hp; 15 Sep; non-tidal shore with cobble, gravel, silt, and driftwood.

Chlaenius sericeus (Forster)–(5); GF, TR; hp; 13 Mar, 23 May, 30 Aug-26 Sep; non-tidal shore under cobble on sand, silt, and gravel; under log in woods; sandy

non-tidal beach under driftwood.

Chlaenius cordicollis Kirby–(4); TR; hp; 22 May, 25-26 Sep; PRG 1918; non-tidal shore with cobble, gravel, silt, and driftwood; creek mouth, silty sand under rock.

Chlaenius impunctifrons Say–(2); GF, TR; hp, pf; 2-16 Jun, 15 Sep; non-tidal shore on gravelly silt and cobble.

Chlaenius tricolor tricolor Dejean–(9); DM, FH, GF, TR; bl, hp, mt; 28 Apr-12 Jul, 15-26 Sep; under coverboard at edge of woods; creek mouth under rock on silt and gravel; riverbank under driftwood on silty sand; in building.

LICININI

Dicaelus elongatus Bonelli–(1); LH; pf; 28 Apr-18 May.

Dicaelus dilatatus dilatatus Say–(1); GF; pf; 11-28 Apr; PRG 1925.

Dicaelus furvus furvus Dejean–(2); LH; hp, pf; 3 Apr, 29 Jul-11 Aug; sandy *Fagus grandifolia* Ehrhart/*Pinus virginiana* Miller woodland under log.

Dicaelus sculptilis intricatus LeConte–(12); GF, TR; hp, pf; 27 Apr-30 Jun, 11Aug-13 Sep; PRG 1905; rich woods under log; dead on sidewalk; in building.

Badister reflexus LeConte–(1); TR; bf; 12 May; PRG 1905; leaf litter in woods.

HARPALINI

Notiobia nitidipennis (LeConte)–(5); CP, TR; hp, mt; 11 Mar-30 Apr, 26 Jul, 29 Sep; under cover board at woodland edge; turf grass duff; under rock in open path through woods.

Notiobia terminata (Say)–(5); DM, GF, TR; bl, hp, mt; 23 Jun-23 Jul; PRG 1902; in building.

Anisodactylus nigerrimus (Dejean)–(7); GF, TR; bf, hp, pt; 15 Apr-6 May; PRG 1923; riverside prairie; open area in woods under rock; leaf litter in woods.

Anisodactylus agricola (Say)–(2); TR; hp, pf; 14 Apr-12 May; under bark.

Anisodactylus melanopus (Haldeman)–(7); CM, GF, RI, RR, TR; bf, hp, mt; 11 Mar-16 May, 25 Sep; PRG 1912; under cobble at river edge; under streamside rock; under driftwood on sandy tidal beach; under log at edge of small agricultural field; leaf litter in woods.

‡*!*Anisodactylus dulcicollis* (LaFerté-Sénectère)–(13); AW, CP, DI, DM, FH, RI, TR; bf, hp, mt; 15 Apr-27 Jun, 19 Sep; rich woods under log; sandy tidal beach under driftwood; dry turf grass; turf grass under log; in spider web; leaf litter in woods, in building.

*!*Anisodactylus ovularis* (Casey)–(1); TR; hp; 17 May; attracted to light on building.

Anisodactylus rusticus (Say)–(4); CI, FH, TR, GF; hp; 22 Mar-17 Apr, 26 Sep; under thin soil over concrete; on dirt road; parking lot.

*!*Anisodactylus sanctaecrucis* (Fabricius)–(1); TR; mt; 19-30 Jun.

Anisodactylus verticalis (LeConte)–(4); GF, TR; hp, mt, pf; 20 May-21 Jul; under rock on sandy roadside.

*!*Anisodactylus laetus* Dejean–(1); GF; bl; 12 Jul.

!*Amphasia sericea* (Harris)–(3); GF; bl; 23 Jun-5 Jul.

Amphasia interstitialis (Say)–(6); GF, PH, RR, TR; bf, hp, pf; 15 Apr-16 Jun; leaf litter in woods; muddy tidal shore under log.

Stenolophus fuliginosus Dejean–(1); DM; mt; 28 May-6 Jun. The specimen is a pale-legged variant.

Stenolophus ochropezus (Say)–(134); AW, DI, DM, FH, GF, TR; bf, bl, hp, mt; 10 Apr-23 Jul, 19-26 Sep; dry vernal pool under rock; moist upland depression under log; leaf litter in woods; leaf litter near water; creek mouth with cobble silt and driftwood; river shore with silty sand under rock; attracted to light on building. This was the most commonly collected carabid during this study, yet it was not reported from Virginia until Hoffman et al. (2006) listed it from 30 Virginia counties. Evans (2008) reported the first record for Fairfax County. We add the first records for Arlington County and the City of Alexandria.

Stenolophus plebejus Dejean–(4); CP, GF; hp, mt; 10 Apr-16 May, 8 Jun; PRG 1907; turf grass hanging over concrete; rocky non-tidal shore with gravel, silt and driftwood.

Stenolophus lecontei (Chaudoir)–(5); DM, GF, TR; bl, hp, mt; 18 Apr-31 May, 2-18 Jul, 15 Oct; sandy non-tidal beach under driftwood; attracted to light on

building.

Agonoleptus conjunctus (Say)–(27); CP, GF, TR; bs, hp, mt; 14 Mar-30 Jun, 18 Sep-21 Oct; rich woods under log; riverside prairie; turf grass over concrete. A subteneral specimen was collected on 2 June 2012.

*!*Agonoleptus rotundatus* (LeConte)–(7); CP, DM, GF; hp, mt; 1-20 May, 26-29 Sep, 7 Nov; turf grass duff; non-tidal shore with sand and mud.

Agonoleptus rotundicollis (Haldeman)–(5); DM, TR; bf, mt; 10 Apr-20 May; PRG 1908. This species was first reported from Virginia by Bousquet (2012) without further details. Roble & Hoffman (2012) listed it from Cumberland and Rockingham counties and we add Fairfax County to the known Virginia range.

*!*Bradycellus nigriceps* LeConte–(1); TR; mt; 19-30 Jun.

Bradycellus rupestris (Say)–(5); GF, PH, TR; bl, hp; mt; 1 May-23 Jun.

*!*Bradycellus tantillus* (Dejean)–(7); DM, GF; hp, mt; 20 May-9 Aug; non-tidal shore with sand and mud. This species was first reported from Virginia by Hoffman (2010).

Bradycellus atrimedeus (Say)–(5); GF, PH, RI; hp; 17 Apr-17 Jun; sandy, silty, tidal shore under sticks; sandy tidal shore under drifwood; non-tidal shore with sand and mud.

Bradycellus badipennis (Haldeman)–(1); GF; mt; 10-30 Apr.

*!*Acupalpus pumilus* Lindroth–(1); GF; mt; 10-30 Apr. This species was first reported for Virginia by Bousquet (2012). It is near its known southern limit in northern Virginia. It has not been recorded in Maryland but is known from West Virginia and Delaware. The species should be considered for state listing because of its rarity in Virginia.

*!*Acupalpus indistinctus* Dejean–(3); DM, TR; hp, mt; 30 May-20 Jun; silty gravel bar in river.

Acupalpus pauperculus Dejean–(1); GF; bs; 24 Jun. This species was previously reported for Virginia by Hoffman et al. (2006) and Evans (2008; based on the specimen cited here).

Acupalpus testaceus Dejean–(5); GF, TR; bl, hp, mt; 20 May-23 Jun; non-tidal shore with cobble, silt, and driftwood; non-tidal shore on sand and mud. Previous records from the Potomac River Gorge were limited to a single capture in 1910, until Evans (2008) reported it during the Potomac Gorge Bioblitz.

Philodes rectangulus (Chaudoir)–(2); DM; mt; 6-20 Jun, 26 Sep. This species was first recorded for Virginia by Hoffman & Roble (2000).

Harpalus vagans LeConte–(7); GF, TR; hp; 19-25 Jun, 29-30 Aug; woodland edge under coverboard; turf grass near woods under board.

Harpalus pensylvanicus (DeGeer)–(25); CP, FH, GF, TR; bl, hp, mt; 6 Jun-26 Oct; under coverboard at edge of woods; turf grass under board; rich woods under log; in building. Evans (2008) recorded the first Potomac River Gorge record of this common, gregarious beetle since 1932. It was observed mating in Fort Hunt Park on 19 September 2012.

*!◊*Harpalus affinis* (Schrank)–(6); DM, FH, RI; hp, mt; 8-23 May, 19-23 Sep; in building; in turf grass; in spider web; on concrete plaza.

†*!◊*Harpalus rubripes* (Duftschmid)–(1); GF; hp; 20 May; under leaf litter on parking lot curb. This is the southernmost station known in North America for this European beetle. The first North American specimen was collected in New Hampshire in 1981. It has since been documented from Nova Scotia to eastern Pennsylvania (Bousquet, 2012), and now northern Virginia.

Selenophorus opalinus (LeConte)–(16); DM, GF; bf, bl, hp, mt; 14 Apr-7 Sep; PRG 1907; under oak leaf litter in open gap on rock outcrop above river; leaf litter near water.

Trichotichnus autumnalis (Say)–(20); AW, DM, FM, GF, PH, RI, TR; bf, hp, lf, mt; 10 Apr-20 May, 23 Jul-8 Aug, 19-21 Oct; leaf litter in woods; sandy tidal beach under driftwood; in debris of rotting stump.

Trichotichnus fulgens (Csiki)–(13); CM, CP, DI, DM, FH, FM, GF, TR; bf, hp; 19 Mar-20 Jun, 30 Aug-13 Sep; under oak leaf litter on rock outcrop above river; woodland edge under log; under rock in woods; dry turf grass; in building.

Cratacanthus dubius (Palisot de Beauvois)–(6); FH; hp; 27 Jun, 19 Sep; under tuft of *Digitaria sanguinalis* (L.) Scop. in dirt infield of baseball diamond; in building.

SPHODRINI

*!*Calathus opaculus* LeConte–(1); GF; bs; 14 Apr; riverside prairie.

Synuchus impunctatus (Say)–(1); TR; pf; 2-16 Jun; PRG 1905.

PLATYNINI

Rhadine caudata (LeConte)–(10); GF, TR; hp, pf; 11 Apr-6 Oct; PRG 1919; under coverboard at edge of woods; in building.

Agonum ferreum Haldeman–(11); DM, GF, PH, TR; bf, hp, mt; 17 Apr-26 Jun; rich woods under log; leaf litter near pond; under rock at trail edge in woods; creek mouth with rock, cobble, sand, and silt; muddy tidal shore under vegetative debris.

Agonum excavatum Dejean–(5); GF, TR; hp, mt; 10 Apr-30 May, 29 Aug; sandy non-tidal beach with silt cakes and sparse vegetation.

Agonum extensicolle (Say)–(20); CP, DM, GF, JP, RI, RP, TR; hp, mt, pf; 10 Apr-23 Jun, 6-25 Sep; sandy cobble tidal beach with *Schoenoplectus*; sandy tidal shore; tidal shore under log; rocky non-tidal shore; rocky non-tidal shore with sand and silt; turf grass under log.

Agonum melanarium Dejean–(4); GF; mt, pf; 10-30 Apr, 24 Aug-8 Sep.

*!*Agonum moerens* Dejean–(1); GF; bl; 28 Jun.

Agonum aeruginosum Dejean–(1); DM; mt; 19-28 Apr.

Agonum striatopunctatum Dejean–(1); CP; hp; 27 May; turf grass.

Agonum octopunctatum (Fabricius)–(1); DM; mt; 7-19 Jul.

!*Agonum punctiforme* (Say)–(55); AW, CM, CP, DI, DM, FH, GF, PH, RI, TR; bf, hp, mt; 11 Mar-30 Jun, 27 Aug-21 Nov; woodland edge under coverboard; woods under log along trail; rocky non-tidal shore on sand and silt; tidal shore, silty sand under driftwood and leaf litter; dry vernal pool under log; under thin soil over concrete; weedy turf grass under board near water; tuff grass under log; under log at edge of small agricultural field; in building. A teneral specimen was captured on 11 June 2012.

Platynus decentis (Say)–(20); CM, FM, GF, LH, TR; bf, pf, hp; 11 Mar-29 Jun, 16-19 Oct; under loose bark; on tree trunk at night; leaf litter in woods; in rotting pine log.

†!*Platynus opaculus* LeConte–(1); DM; mt; 21 Nov-5 Dec. This species has not been recorded from Maryland, North Carolina, or West Virginia. The nearest documented states are Pennsylvania (Bousquet, 2012) and South Carolina (Ciegler, 2000; one specimen). A report of this species from the Potomac River Gorge, without reference to state record status, by Evans (2008), and cited by Roble & Hoffman (2012), is based on a misidentified specimen of *P. decentis*.

Platynus tenuicollis (LeConte)–(27); GF, TR; hp, mt; 10 Apr-30 Jul; PRG 1912; under bark.

Platynus cincticollis (Say)–(23); DM, GF, TR; bl, mt, hp; 10 Apr-26 Sep; rocky non-tidal shore with sand and gravel; shore with silty sand under rock; non-tidal shore with cobble, silt, and driftwood.

PERIGONINI

*!◊*Perigona nigriceps* (Dejean)–(2); TR; bl; 15 Oct. This non-native species was first documented from Virginia by Hoffman & Roble (2000). This is the first record for Fairfax County.

ATRANINI

Atranus pubescens (Dejean)–(1); RP; hp; 11 May; under driftwood on tidal beach with sand and cobble.

ODACANTHINI

Colliuris pensylvanica (Linnaeus)–(1); GF; bs; 24 Jun.

!*Colliuris ludoviciana* (Sallé)–(1); DM; hp; 15 May; gravelly, tidal beach on *Schoenoplectus pungens*.

CTENODACTYLINI

!*Leptotrachelus dorsalis* (Fabricius)–(9); DM; mt; 10-17 May, 16 Jul-28 Aug.

CYCLOSOMINI

Tetragonoderus fasciatus (Haldeman)–(8); GF, PH, TR; bl, hp, mt; 1 May-17 Jun, 9 Sep; under leaf litter on dry sand bank along river; dry, bare sand on bank of river; tidal shore on silty sand. Small colonies of *T. fasciatus* were observed to be active during the day in mottled sunlight on dry sand banks along the river.

LEBIINI

Phloeoxena signata (Dejean)–(4); GF, TR; mt; 21 May-17 Jul. This species was first reported for Virginia by Hoffman (1997) and for the Potomac River Gorge, where it reaches its northern limit, by Steiner & Erwin (2007).

Coptodera aerata Dejean–(10); GF, LH; lf, mt; 1 May-26 Jul; PRG 1922.

Cymindis limbata Dejean–(4); GF; hp, mt; 14 Apr, 31 Jul-17 Aug; PRG 1917; on shrub.

*!*Cymindis platicollis* (Say)–(7); GF; mt; 10 Apr-20 May.

Apenes lucidula lucidula (Dejean)–(2); TR; bl, hp; 13 Mar, 18 Jun; in building.

*!*Apenes sinuata* (Say)–(1); TR; bl; 18 Jun.

†!*Microlestes pusio* (LeConte)–(2); CP; hp; 20 May, 30 Aug; turf grass overhanging concrete. This minute carabid (2.4-2.7 mm) has a known range from southern Ontario, west to eastern South Dakota, and south to eastern Texas, Mississippi, and Tennessee (Bousquet, 2012). Records from the East Coast have only been documented from New York; it has also been found in Pennsylvania.

*!*Apristus latens* (LeConte)–(1); TR; hp; 14 May; dry, sandy riverbank.

Lebia grandis Hentz–(1); GF; bl; 12 Jul. Evans (2008) recorded the first record for this beetle from the Potomac River Gorge since 1924 on Bear Island, Maryland.

Lebia analis Dejean–(2); DM, GF; bl, mt; 20 Jun, 12-26 Sep; PRG 1930.

Lebia lobulata LeConte–(6); AW, GF, TR; bf, bl, mt; 15 Apr-17 May, 3-17 Jul, 19 Sep-21 Oct; leaf litter in woods.

Lebia ornata Say–(4); GF, TR; bl, mt; 25 May-30 Jun. Evans (2008) documented the first record of this species in the Potomac River Gorge since 1913.

Lebia viridipennis Dejean–(22); GF, TR; bl, mt; 1 May-21 Jul. Evans (2008) reported the first record of this species in the Potomac River Gorge since 1930.

Lebia viridis Say–(19), DM, GF, TR; bl, hp, mt; 10 Apr-20 Jul, 3 Oct; on *Solidago bicolor* L.; on *Taraxacum officinale* Weber; attracted to light on building.

Lebia solea Hentz–(6); GF, TR; bl, mt; 21 May-21 Jul; PRG 1930.

Plochionus timidus Haldeman–(1); GF; hp; 15 Jan; PRG 1924; under loose bark of dead standing *Quercus coccinea* Münchhausen.

Calleida viridipennis (Say)–(5); GF, TR; bl, mt; 1-22 May, 21 Jul.

GALERITINI

Galerita bicolor (Drury)–(9); GF, RI, TR; bf, hp, mt, pf; 24 Mar-4 Aug; under bark of fallen log; inside loose wood of rotting log; leaf litter in woods.

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female specimen of *Notiobia nitidipennis*.

LITERATURE CITED

Allen, R.T. 1972. A revision of the genus *Loxandrus* LeConte (Coleoptera: Carabidae) in North America. Entomologica Americana 46: 1-184.

Anderson, J.M., J.C. Mitchell, A.A. Hall, & R.L. Hoffman. 1995. Ground beetles (Coleoptera: Carabidae) from Quantico Marine Corps Base, Virginia. Banisteria 6: 3-16.

Ball, G.E. & Y. Bousquet. 2001. Carabidae Latreille, 1810. Pp. 32-132 *In* R.H. Arnett, Jr. & M.C. Thomas (eds.), American Beetles. Volume I. Archostemata, Myxophaga, Adephaga, Polyphaga: Staphyliniformia. CRC Press, Boca Raton, FL.

Bousquet, Y. 1996. Taxonomic revision of Nearctic, Mexican, and West Indian Oodini (Coleoptera: Carabidae). Canadian Entomologist 128: 433-537.

Bousquet, Y. 2010. Illustrated Identification Guide to Adults and Larvae of Northeastern North American Ground Beetles (Coleoptera: Carabidae). Pensoft, Sofia-Moscow. 562 pp.

Bousquet, Y. 2012. Catalogue of Geadephaga (Coleoptera, Adephaga) of America, north of Mexico. ZooKeys 245: 1-1722.

Bousquet, Y. & A. Larochelle. 1993. Catalogue of the Geadephaga (Coleoptera: Trachypachidae, Rhysodidae, Carabidae including Cicindelini) of America north of Mexico. Memoirs of the Entomological Society of Canada 167: 1-397.

Bousquet, Y., & P.W. Messer. 2010. Redescription of *Stenolophus thoracicus* Casey (Coleoptera, Carabidae, Harpalini), a valid species. ZooKeys 53: 25-31.

Brown, J.W. 2008. The invertebrate fauna of Plummers Island, Maryland. Contribution XXX to the Natural History of Plummers Island, Maryland. Bulletin of the Biological Society of Washington 15: 1-226.

Ciegler, J.C. 2000. Ground beetles and wrinkled bark beetles of South Carolina (Coleoptera: Geadephaga: Carabidae and Rhysodidae). Biota of South Carolina. Volume I. Clemson University, Clemson, S.C. 149 pp.

Cohn, J.P. 2004. The wildest urban river: Potomac River Gorge. BioScience 54: 8-14.

Davidson, R.L. 1995. First Virginia records for ten species of Carabidae (Coleoptera). Banisteria 5: 16-19.

Downie, N.M., & R.H. Arnett, Jr. 1996. The Beetles of Northeastern North America. Volume I. Sandhill Crane Press, Gainesville, FL. 880 pp.

Erwin, T.L. 1981. Natural History of Plummers Island, Maryland, XXVI. The ground beetles of a temperate forest site (Coleoptera: Carabidae): An analysis of fauna in relation to size, habitat selection, vagility, seasonality, and extinction. Bulletin of the Biological Society of Washington 5: 104-224.

Erwin, T.L. 1991. Natural history of the carabid beetles at the BIOLAT Biological Station, Rio Manu, Pakitza, Peru. Revista Peruana de Entomologia 33: 1-85.

Evans, A.V. (ed.). 2008. The 2006 Potomac Gorge Bioblitz. Overview and results of a 30-hour rapid biological survey. Banisteria 32: 3-80.

Evans, A.V. 2009. The forest caterpillar hunter, *Calosoma sycophanta*, an Old World species confirmed as part of the Virginia beetle fauna (Coleoptera: Carabidae). Banisteria 34: 33-37.

Hoffman, R.L. 1997. *Phloeoxena signata* (Dejean), another southern ground beetle discovered in Virginia. Banisteria 10: 30-31.

Hoffman, R.L. 1998. On the occurrence of several species of pterostichine ground beetles in Virginia (Carabidae: Pterostichini). Banisteria 12: 36-40.

Hoffman, R.L. 2010. Ground beetles from Quantico Marine Corps Base: 2. Thirty additional species from recent collections (Coleoptera: Carabidae). Banisteria 36: 20-24.

Hoffman, R.L., & S.M. Roble. 2000. Fourteen ground beetles new to the Virginia fauna. Banisteria 16: 36-41.

Hoffman, R.L., S.M. Roble, & R.L. Davidson. 2006. Thirty ground beetles new to the fauna of Virginia, and a milestone (Coleoptera: Carabidae). Banisteria 27: 16-30.

Knisley, C.B., & T.D. Schultz. 1997. The Biology of Tiger Beetles and a Guide to the Species of the South Atlantic States. Virginia Museum of Natural History Special Publication 5. Martinsville, VA. 210 pp.

Larochelle, A., & M.C. Larivière. 2003. A Natural

History of the Ground-Beetles (Coleoptera: Carabidae) of America North of Mexico. Pensoft Publishers, Sofia-Moscow. 583 pp.

Löbl, I. & A. Smetana. 2003. Catalogue of Palaearctic Coleoptera. Volume I. Apollo Books, Stenstrup, Denmark. 819 pp.

Maddison, D.R. 2008. Systematics of the North American beetle subgenus *Pseudoperyphus* (Coleoptera: Carabidae: *Bembidion*) based upon morphological, chromosomal, and molecular data. Annals of the Carnegie Museum 77: 147-193.

Mani, M.S. 1968. Ecology and Biogeography of High Altitude Insects. Dr. W. Junk b.v. Publishers, The Hague, The Netherlands. 527 pp.

Matthews, J.V. 1979. Late Tertiary carabid fossils from the Alaska and the Canadian Archipelago. Pp. 425-445 *In* T.L. Erwin, G.E. Ball, D.R. Whitehead, & A.L. Halpern (eds.), Carabid Beetles: Their Evolution, Natural History, and Classification. Proceedings of the First International Symposium of Carabidology, Smithsonian Institution, Washington, D.C., August 21, 23, and 25, 1976. Dr. W. Junk b.v., Publishers, The Hague, The Netherlands.

Matthews, J.V., & A. Telka. 1997. Insect fossils from the Yukon. Pp. 911-962 *In* H.V. Danks & J.A. Downes (eds.), Insects of the Yukon. Biological Survey of Canada (Terrestrial Arthropods). Ottawa.

Roble, S.M. 2013. Natural heritage resources of Virginia: rare animal species. Natural Heritage Technical Report 13-05. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 46 pp.

Roble, S.M., & R.L. Hoffman. 2012. New and additional records of ground beetles and wrinkled bark beetles for Virginia (Coleoptera: Carabidae, Rhysodidae). Banisteria 40: 42-48.

Staines, C.L., & S.L. Staines. 2011. The Carabidae (Insecta: Coleoptera) of Eastern Neck National Wildlife Refuge, Maryland. Banisteria 38: 71-84.

Steiner, W.E., Jr., & T.L. Erwin. 2007. *Phloeoxena signata* (Dejean): northern range extensions to Maryland and Tennessee, U.S.A., and the first record for Costa Rica (Coleoptera: Carabidae). Coleopterists Bulletin 61: 224-226.

Steury, B.W. 2011. Additions to the vascular flora of the George Washington Memorial Parkway, Virginia, Maryland, and the District of Columbia. Banisteria 37: 3-20.

Steury, B.W., G.P. Fleming, & M.T. Strong. 2008. An emendation of the vascular flora of Great Falls Park, Fairfax County, Virginia. Castanea 73: 123-149.

Stork, N.E. 1984. Additions to the list of Carabidae (Coleoptera) in the fauna of Plummers Island, Maryland. Coleopterists Bulletin 38: 137-141.

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Ichthyofaunal Survey of Tributaries of the Appomattox River System, Virginia, 1986-87

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ABSTRACT

An extensive survey of the fish fauna of tributaries of the Appomattox River system, Virginia was conducted during 1986-87. A total of 81 collections was made, including two in the mainstem of the system. We collected 17,210 fish representing 11 families, 35 genera, and 55 species. Two species (*Notropis volucellus*, Mimic Shiner; and *Moxostoma cervinun*, Blacktip Jumprock) were new records for the Appomattox system. Three species (*Notropis bifrenatus*, Bridle Shiner; *Anguilla rostrata*, American Eel; and *Acantharchus pomotis*, Mud Sunfish) are listed as Species of Greatest Conservation Need. A limited sport fishery was determined for 13 species.

Key words: Appomattox River, fish survey, habitat.

INTRODUCTION

We conducted an extensive survey of the fish fauna in tributaries of Virginia's Appomattox River system during 1986-87 to ascertain species composition and relative abundance for the purpose of inventorying species present and assessing the sport fishery. The objective of this survey was to target the tributary streams (generally first and second order). All but two of the collections were on tributary streams. Relatively little was known about the fish fauna in the Appomattox system prior to this survey. The Fish and Wildlife Information System (FWIS) of the Virginia Department of Game and Inland Fisheries (VDGIF) shows 12 fish collection series for the Appomattox system prior to 1986. These collections were made from 1935-1983. Apparently the results of most of the collections were not published.

STUDY AREA

The Appomattox River is a major tributary of the James River in central Virginia. From its source in northeastern Appomattox County, the Appomattox River flows generally southeastward to Farmville where it makes a large arc northeastwardly and then southeastwardly passing through Petersburg to Hopewell, where it merges with the James River. The Appomattox River originates in the Piedmont Foothill Zone subprovince, passes through the Piedmont Lowlands subprovince, and merges with the James River in the Coastal Plain. Jenkins & Burkhead (1994) reviewed in detail the characteristics of these physiographic regions with discussion including topography, soil types, and stream hydrology. The Appomattox River is about 258 rkm in length (Jenkins & Burkhead, 1994), dropping in elevation from 115.8 m at its source to 1 m at its confluence with the James River (Fry et. al., 2011). The watershed area is about 3,481 km^2. Discharge at the Matoaca U.S.G.S. gaging station, situated in Chesterfield County about 4.8 km downstream of the Brasfield Dam, averages 38.66 m^3/s. The Appomattox River watershed is 42.4% deciduous forest, 18.1% evergreen forest, 4.1% mixed forest, 16.8% pasture hay, and 1.8% cultivated crop (Fry et. al., 2011).

Four dams of greatly varied age, height, and condition are present on the lower Appomattox River. History and structural characteristics of these dams are reviewed by EA Engineering, Science, and Technology, Inc., 2012. The farthest downstream is Harvell Dam, located at the Great Falls of the Appomattox about 100 m upstream of the head of tide and situated between VA Rt. 36 and US Rt. 1. The dam was reportedly built about 1856. It is about 3 m high, effectively preventing upstream fish passage. To satisfy a requirement of the Federal Energy Regulatory Commission, a Denil fishway was built in 1998 which allowed some fish passage until the hydropower facility ceased operation in 2004. About 1 km upstream of Harvell Dam is Battersea Dam, which is about 3.1 m high but sufficiently breached for fish passage. The Abutment Dam (2-3 m high) is about 8.2 km upstream of Battersea Dam. A Denil fishway was built on the Abutment Dam in 2003, and in 2009, a middle section of the dam (approximately 33 m wide) collapsed, eliminating this barrier to fish passage. About 2.1 km upstream of the Abutment Dam is Brasfield Dam (22 m high) constructed in 1966-67, which impounds Lake Chesdin (1,254 ha), the only major reservoir in the system. A fish lift was completed on Brasfield Dam in 2004 in mitigation for the installation of a hydropower unit in 1993. Brasfield Dam is the farthest upstream obstacle to fish passage on the Appomattox River. Approximately 192 km of the river is available for anadromous fish spawning above this point.

The section of the Appomattox River from Brasfield to Harvell Dam was designated in 1977 as a Virginia Scenic River by the Virginia Department of Conservation and Recreation.

MATERIALS AND METHODS

We made 79 collections between April and August, 1986, all but 15 of these in April and May. Two additional collections were made on 28 July 1987, for a survey total of 81 collections. The locations of collection sites are presented in Figure 1 and Table 1.

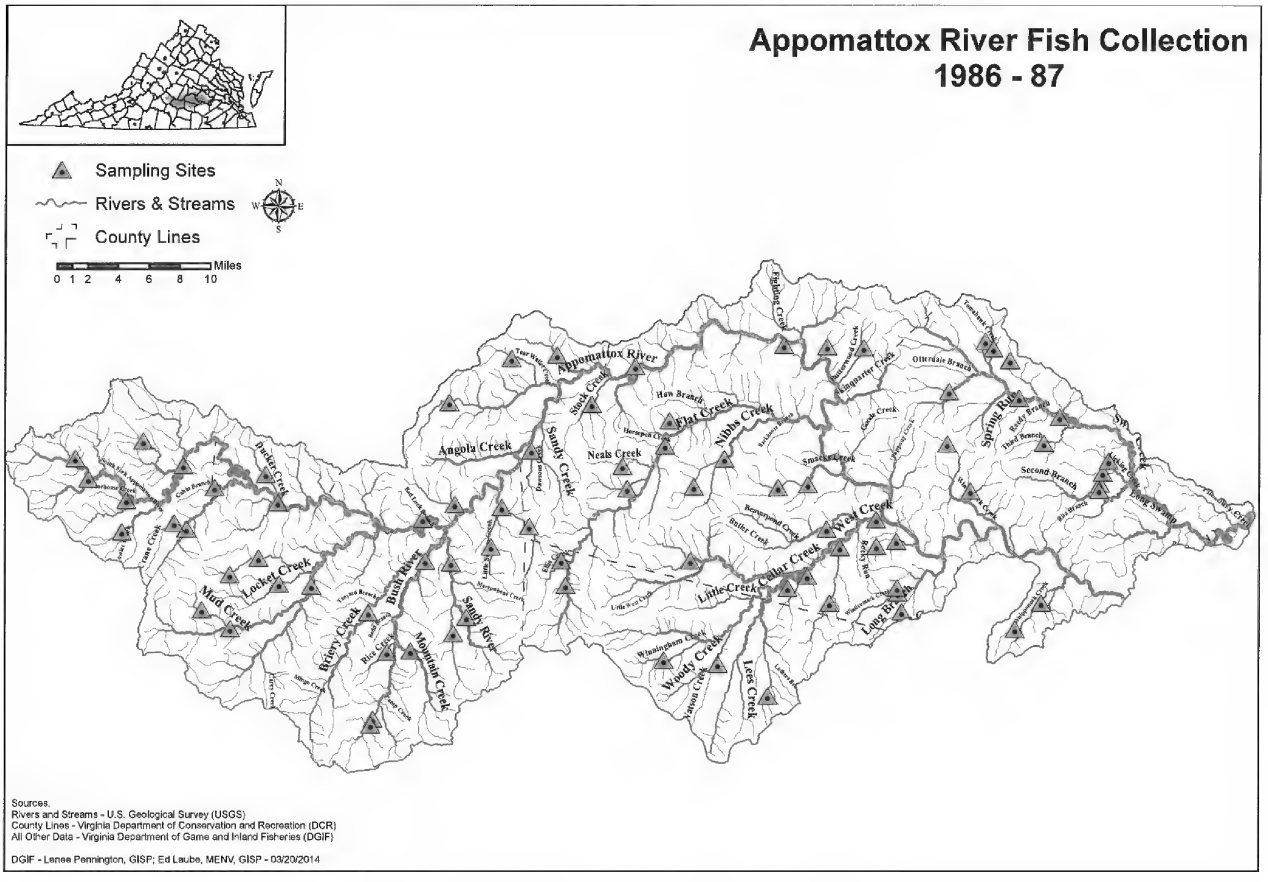

Fig. 1. Map of fish collection sites in the Appomattox River system, Virginia, 1986-87.

Table 1. Appomattox River fishes survey, 1986-87.

Site	County	Stream	Route	USGS Topo Map	Date	# species collected	# fish collected
183	Dinwiddie	Whippernock Cr.	708	Church Road	3/04/86	16	67
184	Dinwiddie	Whippernock Cr.	627	Church Road	3/04/86	6	8
185	Chesterfield	Rita Br.	636	Beach	3/04/86	1	1
186	Chesterfield	Second Br.	636	Beach	3/04/86	8	80
187	Chesterfield	First Br.	636	Beach	3/04/86	9	29
188	Chesterfield	Licking Cr.	636	Beach	3/04/86	12	26
189	Chesterfield	Swift Cr.	653	Chesterfield	3/04/86	9	13
190	Chesterfield	Rocky Run	653	Beach	3/04/86	3	8
191	Chesterfield	Tomahawk Cr.	652	Hallsboro	4/04/86	6	12
192	Chesterfield	Little Tomahawk Cr.	652	Hallsboro	4/04/86	4	18
193	Chesterfield	Nuttree Br.	652	Hallsboro	4/04/86	12	202
194	Chesterfield	Swift Cr.	360	Hallsboro	4/04/86	9	88
195	Chesterfield	Horsepen Cr.	667	Hallsboro	4/04/86	2	2
196	Chesterfield	Winterpock Cr.	655	Winterpock	4/04/86	3	9
197	Chesterfield	unnam. trib. Surline Br.	602	Winterpock	4/04/86	11	91
198	Amelia	Namozine Cr.	622	Hebron	8/04/86	8	19
199	Amelia	Long Br.	600	Hebron	8/04/86	8	92
200	Amelia	Winticomack Cr.	600	Hallsboro	8/04/86	6	12
201	Amelia	unnam. trib. Winticomack Cr.	600	Mannboro	8/04/86	7	17
202	Amelia	Sweathouse Cr.	682	Wellville	8/04/86	8	24
203	Amelia	Spindler's Cr.	615	Wellville	8/04/86	17	55
204	Amelia	Deep Cr.	615	Wellville	8/04/86	8	18
205	Amelia	South Buckskin Cr.	640	Jetersville	8/04/86	7	25
206	Amelia	N. B. Nibbs Cr.	687	Jetersville	8/04/86	14	112
207	Amelia	Little Cr.	642	Jetersville	9/04/86	9	43
208	Amelia	Neal's Cr.	642	Jetersville	9/04/86	21	547
209	Amelia	Flat Cr.	644	Ballsville	9/04/86	6	13
210	Amelia	unnam. trib. Flat Cr.	667	Ballsville	9/04/86	10	88
211	Amelia	Nibb's Cr.	681	Amelia Courthouse	9/04/86	12	61
212	Amelia	Puckett's Br.	685	Church Road	22/04/86	9	57
213	Amelia	Horsepen Br.	622	Mannboro	22/04/86	5	12
214	Amelia	Beaverpond Cr.	153	Amelia Courthouse	22/04/86	17	103
215	Amelia	Sweathouse Cr.	708	Mannboro	22/04/86	2	3
216	Amelia	Smack's Cr.	627	Amelia Courthouse	22/04/86	2	5
217	Amelia	Smack's Cr.	628	Amelia Courthouse	22/04/86	14	166
218	Amelia	Stock Cr.	644	Cumberland	22/04/86	14	51
219	Amelia	Dawson's Cr.	619	Cumberland	22/04/86	16	95
220	Amelia	Sayler's Cr.	617	Deatonville	22/04/86	15	148
221	Prince Edward	Buffalo Cr.	658	Farmville	23/04/86	10	20
222	Prince Edward	Locket Cr.	650	Prospect	23/04/86	14	197
223	Prince Edward	Falling Cr.	626	Prospect	23/04/86	7	104
224	Prince Edward	Falling Cr.	657	Prospect	23/04/86	7	290
225	Prince Edward	Vaughn's Cr.	627	Prospect	23/04/86	13	244
226	Prince Edward	Mud Cr.	639	Abilene	23/04/86	10	60
227	Prince Edward	S. F. Spring Cr.	664	Abilene	23/04/86	19	130
228	Prince Edward	Rice Cr.	647	Hampden Sydney	24/04/86	22	216
229	Prince Edward	Evans Cr.	632	Hampden Sydney	24/04/86	21	110
230	Prince Edward	Bush R.	633	Keysville	24/04/86	13	95
231	Prince Edward	Briery Cr.	665	Hampden Sydney	24/04/86	15	79
232	Prince Edward	Little Sandy R.	612	Green Bay	24/04/86	23	263
233	Nottoway	Bland Cr.	605	Wellville	19/05/86	15	106
234	Nottoway	Woody Cr.	607	Crewe East	19/05/86	10	169
235	Nottoway	Winningham Cr.	617	Crewe East	19/05/86	15	221
236	Nottoway	Flat Cr.	629	Deatonville	19/05/86	21	405
237	Nottoway	Ellis Cr.	628	Deatonville	19/05/86	17	581
238	Prince Edward	Bush R.	460	Rice	20/05/86	11	56
239	Prince Edward	Sandy R.	460	Rice	20/05/86	13	60
240	Prince Edward	Sayler's Cr.	600	Rice	20/05/86	16	477
241	Prince Edward	Sandy R.	606	Green Bay	20/05/86	15	115
242	Prince Edward	Mountain Cr.	628	Green Bay	20/05/86	19	221
243	Cumberland	Bad Luck Br.	600	Rice	20/05/86	17	165
244	Buckingham	Ducker Cr.	725	Prospect	20/05/86	7	242
245	Cumberland	Green Cr.	600	Rice	21/05/86	11	87
246	Cumberland	Tear Wallet Cr.	641	Cumberland	21/05/86	18	178
247	Cumberland	Little Guinea Cr.	654	Cumberland	21/05/86	16	43
248	Powhatan	unnam. trib. Appomattox R.	681	Ballsville	21/05/86	15	90
249	Powhatan	Butterwood Cr.	604	Clayville	8/07/86	14	288
250	Powhatan	Skipper's Cr.	603	Clayville	8/07/86	8	66
251	Cumberland	Little Guinea Cr.	640	Hillcrest	8/07/86	22	658
252	Appomattox	S. F. Appomattox R.	627	Pamplin	9/07/86	23	736
253	Appomattox	Rocky Run	631	Vera	9/07/86	22	1273
254	Appomattox	Fish Pond Cr.	614	Holiday Lake	9/07/86	13	274
255	Appomattox	Appomattox R.	626	Pamplin	9/07/86	7	228
257	Appomattox	Crane Cr.	600	Pamplin	13/08/86	19	475
258	Appomattox	Poorhouse Cr.	627	Pamplin	13/08/86	24	958
259	Appomattox	Suanee Cr.	619	Pamplin	13/08/86	19	132
260	Prince Edward	Harris Cr.	651	Prospect	14/08/86	33	793
261	Prince Edward	Vaughn's Cr.	609	Prospect	14/08/86	26	595
262	Prince Edward	Sayler's Cr.	619	Rice	14/08/86	26	478
269	Amelia	Deep Cr.	612	Mannboro	28/07/87	31	993
270	Amelia	Appomattox R.	682	Chula	28/07/87	11	51

Most of our sampling was by electrofishing using a portable 230 volt DC generator with probes and 30 m cable. Rotenone was used at 21 sites. Seining (15.2 m minnow seine) was our exclusive sampling method at one site, and we used both trap nets and seining at another site. For rotenone sampling, a block net (minnow seine) was set at the downstream point of the sample site to prevent fish from escaping and to assist in fish capture. Sampling effort was intensive. Sample length at the rotenone sites ranged from 45.7-219.5 m. Sample length at the electrofishing sites ranged from 24.4-137.2 m.

We made a conscious attempt to collect all fishes observed in the sampling, with the exception of American Eels (*Anguilla rostrata*) which were sometimes simply enumerated in passing. Individual fish were identified to species with the exception of Johnny and Tessellated Darters (*Etheostoma nigrum* and *E. olmstedi*; see species account). For these two sibling and problematic species, all specimens were considered Johnny Darter because this species is generally found above the Fall Line whereas the Tessellated Darter is generally found in the Coastal Plain of the James River drainage.

Some fish were identified and enumerated in the field. However, most specimens were preserved in formalin (10%) and then stored in ethanol (70%) for identification in the lab. All fish were measured for total length (TL) by inch group. Many of the preserved specimens were taken to Roanoke College where Dr. Robert E. Jenkins either identified or confirmed the species identification made by us. A few such specimen lots were retained at Roanoke College. Almost all of the collections were stored by VDGIF. Due to storage space limitation, many of the VDGIF specimens were later discarded, with the notable exception of the darters and a few other special interest fishes, which were deposited with the North Carolina State Museum of Natural Sciences in Raleigh, NC.

Channel width and stream depth were measured (in feet) and recorded as averages. Other physical habitat characteristics were described and subjectively rated as follows: stream flow – slow, moderate, or swift; fish cover – poor, fair, good, or excellent (with notations on type such as macrophytes, undercut banks, brush, boulders, etc.); aquatic macrophytes – none, sparse, common, or abundant (with notations on type); substrate – silt, sand, gravel, cobble, boulders, bedrock, or mud; water clarity – clear, slightly turbid, or very turbid; and riparian zone – forest canopy, pasture, agricultural field, etc. Water temperature was determined with a YSI meter and recorded in degrees Celsius.

Chemical habitat parameters monitored were specific conductance, pH, total hardness, and total alkalinity. Specific conductance was determined with a YSI meter. The other chemical parameters were determined with a Hach Water Quality monitoring kit.

Collection data (with the exception of some habitat notes) were stored in the FWIS database of VDGIF.

RESULTS

Habitat

Most physical habitat characteristics were fairly uniform over the entire drainage. For example, of the 81 collection sites, stream flow was rated slow or moderate at 97.5% (only two sites were rated swift), water clarity was rated clear or slightly turbid at 88.6%, and aquatic macrophyte abundance was rated none or sparse at 96.2%. Fish cover was more diverse: it was rated fair or good at 62.0% and poor at 29.1% of the sites; only seven sites were rated excellent for fish cover. With the exception of the two mainstem sites, stream width ranged from 1.2– 9.1 m but was generally within 2.4-4.6 m. Mean stream depth was generally 0.15-0.46 m. Substrate type ran the gamut from silt to bedrock, with most sites exhibiting several types which were not quantified.

Of the chemical parameters, specific conductance ranged from 25 to 130 µs/cm ($\bar{x}$ = 73.5 µs/cm, SD = 25.35), total hardness ranged from 17 to 68 ppm ($\bar{x}$ = 37.0 ppm, SD = 12.58); and total alkalinity ranged from 17 to 103 ppm ($\bar{x}$ = 62.8 ppm, SD = 22.55). In general, the higher conductivity (>100 µs/cm) and alkalinity (>100 ppm) sites were in the upper part of the system (notably in Prince Edward, Nottoway, and Buckingham counties). pH ranged from 6-7.4, with the mode (78.7%) falling within 6.7-7.2. In general, the more acidic sites were in the lower part of the drainage.

Water temperature ranged from 11.5° C (24 April 1986, site 230) to 28° C (9 July 1986, site 255). In general, water temperature was below 20° C until mid-May. Of the 49 collections made in April, water temperature was 16° C or less at 31 sites.

Ichthyofauna

Fifty-five species of fish representing 11 families and 35 genera were collected (Table 2). Individual species accounts with habitat notes are presented phylogenetically by family and alphabetically by genus and species.

Table 2. Fish species collected in the Appomattox River system, 1986-1987.

Family	Species	Common Name	# sites	# specimens	Mean # specimens/site
Anguillidae	*Anguilla rostrata*	American Eel	9	12	1.33
Clupeidae	*Dorosoma cepedianum*	Gizzard Shad	2	32	16.00
Esocidae	*Esox niger*	Chain Pickerel	23	48	2.09
Umbridae	*Umbra pygmaea*	Eastern Mudminnow	14	27	1.93
Cyprinidae	*Campostoma anomalum*	Central Stoneroller	16	465	29.06
Cyprinidae	*Chrosomus oreas*	Mountain Redbelly Dace	26	556	21.38
Cyprinidae	*Clinostomus funduloides*	Rosyside Dace	38	681	17.92
Cyprinidae	*Cyprinella analostana*	Satinfin Shiner	24	332	13.83
Cyprinidae	*Exoglossum maxillingua*	Cutlip Minnow	5	46	9.20
Cyprinidae	*Hybognathus regius*	Eastern Silvery Minnow	16	198	12.38
Cyprinidae	*Luxilus cerasinus*	Crescent Shiner	9	243	27.00
Cyprinidae	*Luxilus cornutus*	Common Shiner	20	849	42.45
Cyprinidae	*Lythrurus ardens*	Rosefin Shiner	17	424	24.94
Cyprinidae	*Nocomis leptocephalus*	Bluehead Chub	65	2877	44.26
Cyprinidae	*Nocomis micropogon*	River Chub	3	60	20.00
Cyprinidae	*Notemigonus crysoleucas*	Golden Shiner	16	45	2.81
Cyprinidae	*Notropis amoenus*	Comely Shiner	3	19	6.33
Cyprinidae	*Notropis bifrenatus*	Bridle Shiner	2	5	2.50
Cyprinidae	*Notropis procne*	Swallowtail Shiner	20	298	14.90
Cyprinidae	*Notropis volucellus*	Mimic Shiner	2	10	5.00
Cyprinidae	*Rhinichthys atratulus*	Blacknose Dace	29	588	20.28
Cyprinidae	*Rhinichthys cataractae*	Longnose Dace	5	21	4.20
Cyprinidae	*Semotilus atromaculatus*	Creek Chub	37	561	15.16
Cyprinidae	*Semotilus corporalis*	Fallfish	26	582	22.38
Catostomidae	*Erimyzon oblongus*	Creek Chubsucker	38	257	6.76
Catostomidae	*Hypentelium nigricans*	Northern Hog Sucker	13	42	3.23
Catostomidae	*Moxostoma cervinum*	Blacktip Jumprock	1	4	4.00
Catostomidae	*Thoburnia rhothoeca*	Torrent Sucker	34	713	20.97
Ictaluridae	*Ameiurus natalis*	Yellow Bullhead	17	37	2.18
Ictaluridae	*Ameiurus nebulosus*	Brown Bullhead	15	29	1.93
Ictaluridae	*Ictalurus punctatus*	Channel Catfish	2	4	2.00
Ictaluridae	*Noturus insignis*	Margined Madtom	43	621	14.44
Aphredoderidae	*Aphredoderus sayanus*	Pirate Perch	52	273	5.25
Poeciliidae	*Gambusia holbrooki*	Eastern Mosquitofish	6	19	3.17
Centrarchidae	*Acantharchus pomotis*	Mud Sunfish	7	11	1.57
Centrarchidae	*Centrarchus macropterus*	Flier	8	12	1.50
Centrarchidae	*Enneacanthus gloriosus*	Bluespotted Sunfish	12	53	4.42
Centrarchidae	*Lepomis auritus*	Redbreast Sunfish	45	684	15.20
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	35	127	3.63
Centrarchidae	*Lepomis gulosus*	Warmouth	17	29	1.71
Centrarchidae	*Lepomis macrochirus*	Bluegill	45	406	9.02
Centrarchidae	*Lepomis microlophus*	Redear Sunfish	2	3	1.50
Centrarchidae	*Micropterus dolomieu*	Smallmouth Bass	8	47	5.88
Centrarchidae	*Micropterus punctulatus*	Spotted Bass	6	52	8.67
Centrarchidae	*Micropterus salmoides*	Largemouth Bass	9	14	1.56
Centrarchidae	*Pomoxis annularis*	White Crappie	1	3	3.00
Centrarchidae	*Pomoxis nigromaculatus*	Black Crappie	3	7	2.33
Percidae	*Etheostoma flabellare*	Fantail Darter	43	452	10.51
Percidae	*Etheostoma fusiforme*	Swamp Darter	13	35	2.69
Percidae	*Etheostoma longimanum*	Longfin Darter	3	59	19.67
Percidae	*Etheostoma nigrum*	Johnny Darter	64	1653	25.83
Percidae	*Etheostoma vitreum*	Glassy Darter	13	163	12.54
Percidae	*Perca flavescens*	Yellow Perch	3	8	2.67
Percidae	*Percina notogramma*	Stripeback Darter	30	139	4.63
Percidae	*Percina peltata*	Shield Darter	4	29	7.25

Family Anguillidae – Freshwater Eels

Anguilla rostrata, American Eel: This was the only diadromous species found in the survey. It was not abundant (only 12 specimens collected) and was generally restricted to the lower portion of the system. One outlier was found in Falling Creek (site 223) in Prince Edward County. American Eel is listed as a Species of Greatest Conservation Need (Tier IV) in the Virginia Wildlife Action Plan (VDGIF, 2014).

Family Clupeidae – Herrings

Dorosoma cepedianum, Gizzard Shad: Gizzard Shad was collected at only two sites: Appomattox River mainstem at the Amelia Wildlife Management Area (site 270) and lower Deep Creek (site 269). The streams at both sites were relatively large (mean width about 12.2 m), which is preferred habitat for Gizzard Shad compared with small tributaries. Since the vast majority of sampled sites were small tributaries, the scarcity of Gizzard Shad in the survey was expected. All specimens were adults ranging from 7-11 inches TL.

Family Umbridae – Mudminnows

Umbra pygmaea, Eastern Mudminnow: The Eastern Mudminnow was found at 14 sites, mostly in the central part of the system. The species was never abundant; most sites yielded a single specimen. At sites yielding higher numbers, habitat characteristics in common included: relatively small stream (mean width and depth of 2.4 m and 15 cm); substrate of sand, gravel, and cobble; abundant fish cover; and pH 7.0.

Family Cyprinidae – Minnows

Campostoma anomalum, Central Stoneroller: This species was fairly common but restricted to the upper system. Most stations yielded <15 specimens with the notable exceptions of Crane Creek (site 257), Poorhouse Creek (site 258), and Rocky Run (site 253), which collectively yielded 79.1% of the total specimens. The high count at these sites was undoubtedly influenced by the sampling method (rotenone) and survey length (76-134 m). The substrate at all three sites was very silty, suggesting a high turbidity tolerance by this species. Habitat characteristics common at each site were: riffle/run habitat with pools to 0.8 m depth; fish cover fair to good; and pH slightly alkaline (7.1-7.4). Each site was fully canopied, which had a noticeable influence on water temperature (20.0° C on August 13).

Chrosomus oreas, Mountain Redbelly Dace: This dace was fairly common and widely distributed in the upper and middle system. It was generally associated with Blacknose and Longnose Daces. Habitat characteristics at the five sites with the higher counts (>50 fish/site) included: stream width, 1.5-3 m; water clarity either clear or slightly turbid; substrate of sand/gravel/cobble; flow either slow or moderate; fish cover fair to excellent; and pH 6.9-7.2.

Clinostomus funduloides, Rosyside Dace: This minnow was collected at 38 sites widely dispersed in the system but was more concentrated in the upper portion. Although the total number of specimens collected was relatively high, this species was generally uncommon with usually <10 specimens collected per site. A notable exception was Neal's Creek (site 208) in Amelia County where 199 Rosyside Dace were collected. Habitat characteristics at this site were: mostly riffle/run with pools to 1 m depth; mean stream width and depth, 2.4 m and 15 cm; moderate stream flow; substrate of sand/ gravel/cobble; excellent fish cover (logs, brush, under-cut banks, rocks); slightly turbid water; neutral pH; and complete forest cover with beaver dam upstream. Although this species prefers clear water, it apparently tolerates some turbidity. All three sites where the Rosyside Dace was most abundant had slightly turbid water. Rosyside Dace was always found associated with Blacknose Dace.

Cyprinella analostana, Satinfin Shiner: Another common cyprinid, 332 specimens were collected at 24 widely distributed sites, but usually with fewer than 10 collected at each site. Notable exceptions were Sayler's Creek (site 262) and Deep Creek (site 269), with counts of 65 and 97, respectively. Sampling method (rotenone) and survey length were probably factors in determining the high counts at these two sites.

Exoglossum maxillingua, Cutlip Minnow: The Cutlip Minnow was collected at only five sites, all in the upper system (Appomattox and Prince Edward counties). The species was rare (46 specimens collected) and restricted in distribution. Two sites (#252, S. Fork Appomattox River and #253, Rocky Run) collectively yielded 78.3% of the total specimens. Habitat characteristics at these two sites included: primarily riffle/run with a few pools to depth of 0.8 m; substrate of sand/gravel/cobble with a few boulders; mean stream width and depth 3.6 m and 23 cm; fish cover classified as good or excellent; water clarity rated clear; stream flow rated slow; and slightly alkaline pH.

Hybognathus regius, Eastern Silvery Minnow: This species was found at 16 sites scattered over the upper two-thirds of the system. It was relatively uncommon with usually <10 specimens/site. Two sites (Harris Creek, #260 and Little Guinea Creek, #251) yielded a relatively high number of specimens with counts of 34 and 64, respectively. The substrate at Harris Creek was very silty. Otherwise, there were no distinguishing habitat characteristics for these two streams.

Luxilus cerasinus, Crescent Shiner: This shiner was reported from nine sites, all in the upper system. Previously, it was known from only one site in the Appomattox system (Holiday Creek just below Holiday Lake), where it is believed to have been a bait fish introduction, probably from the Roanoke drainage (Jenkins & Burkhead, 1994).

Of the nine reported collections, only three (Evans Creek, site 229; Bush River, site 230; and Appomattox River, site 255) were confirmed by Jenkins as Crescent Shiner (voucher specimens for sites 229 and 230 are at Roanoke College; that Jenkins identified Crescent Shiner at site 255 is suggested from our notes on the field sheet). An additional collection at Roanoke College (Mud Creek, site 226) has three vouchers that are either *L. cerasinus* and/or *L. cerasinus* x *cornutus* hybrids (R. E. Jenkins, pers. comm.). Also, one specimen from site 229 may be a hybrid *L. cerasinus* x *L. cornutus;* it was taken with eight specimens each of *L. cerasinus* and *L. cornutus*.

Crescent Shiners were reported from five additional collections (using preserved specimens), but the field sheets are not checked to show that identification was made or confirmed by Jenkins (as was our routine practice). Since the specimens were later discarded, identification cannot be verified. These five "questionable" collections are: Vaughn's Creek (Co. Rt. 627), site 225; S. Fork Spring Creek, site 227; Fish Pond Creek, site 254; Crane Creek, site 257; and Vaughn's Creek (Co. Rt. 609), site 261.

The Crescent Shiner was uncommon in this survey, with 243 fish reported. It was most abundant at sites 255 (Appomattox River mainstem) and 261 (Vaughn's Creek), where 67 and 95 specimens, respectively, were taken. Of these two collections, only the Appomattox River specimens may have been identified by Jenkins.

The habitat at the four sites with confirmed Crescent and/or hybrid Common Shiners is as follows. Three sites were either riffle or riffle/run/pool with a few pools to 0.6 m depth; the other site was essentially a run. The substrate varied considerably from very silty/clay to clay/gravel/bedrock to sand/gravel. Mean stream width and depth ranged from 2.4-6.1 m and 15-46 cm, respectively. The stream bottom was non-vegetated at all four sites. Fish cover was rated fair at three sites and poor at one. Water clarity was rated clear at two sites and slightly turbid at two. Chemical habitat parameters were: pH 7.0-7.2, specific conductance 32–88 µs/cm, total hardness 17-51 ppm, and total alkalinity 51-86 ppm.

Luxilus cornutus, Common Shiner: The Common Shiner was indeed common with 849 fish collected at 20 sites. This was the second most abundant cyprinid in the survey. All sites were in the upper half of the system. Streams with a very high number of Common Shiners in the sample were South Fork Appomattox River (site 252), Rocky Run (site 253), and Poorhouse Creek (site 258), with counts of 93, 186, and 216 fish, respectively. However, these high counts were undoubtedly influenced by the sampling method (rotenone) and survey length (128-152 m). Habitat at these sites was very similar. Rocky Run and Poorhouse Creek had a heavy small-sediment load, suggesting that the watershed disturbance had long duration; by inference, the Common Shiner is turbidity tolerant. Otherwise, the substrate at both sites was the same: sand/gravel/ cobble/bedrock (very rocky).

Lythrurus ardens, Rosefin Shiner: This was another common cyprinid; 424 specimens were collected at 17 sites widely distributed over the system. Generally <10 specimens were taken per site. Exceptions were Harris Creek (site 260), Rocky Run (site 253), and Appomattox River (site 255) which collectively yielded 60.1% of the total specimens. Habitat characteristics at each site included: riffle/run with pools to 0.76 m; substrate of sand/silt/pea gravel; water clarity rated clear; and pH 7.1-7.4. The main difference among the sites was stream width; the Appomattox River (mean width 6.1 m) was about twice that of the others.

Nocomis leptocephalus, Bluehead Chub: With 2,877 specimens collected at 65 sites, the widely distributed Bluehead Chub was the most abundant cyprinid in the survey. It was most abundant in the upper system (Nottoway, Prince Edward, and Appomattox counties) where the streams were slightly alkaline (pH 7.1-7.4) and had higher conductivity (80-102 micros/cm). Bluehead Chubs were 3-6 inches TL.

Nocomis micropogon, River Chub: River Chub was collected at only three sites. Two sites (260, Harris Creek and 261, Vaughn's Creek) are in the upper system (Prince Edward County) where the species was not common (total of seven fish collected). The third site (269, Deep Creek) is in the lower system (Amelia County), where the fish was common (n = 53). The

only apparent habitat difference is stream size: both Prince Edward County sites were relatively small (mean width 3-4.6 m), whereas the Amelia County site was large (mean width, 12.2 m). However, the relatively high count at the Deep Creek site was heavily influenced by a large number of young-of-year (YOY) fish (51 of the 53 specimens were 0-3 inches TL). River Chubs ranged up to 8 inches TL.

Notemigonus crysoleucas, Golden Shiner: Found in low abundance (generally one or two specimens/site) at 16 sites (most in the middle portion of the system), the Golden Shiner was not common or widely distributed. Water turbidity and temperature were high at the sites with the higher counts (due to pasture and/or agricultural fields bordering the sites), showing that this shiner is indeed tolerant of these conditions as reported by Jenkins & Burkhead (1994).

Notropis amoenus, Comely Shiner: The Comely Shiner was a rare cyprinid in this survey. Collectively, only 19 specimens were taken at three sites, all in the middle of the system. Two sites (Flat Creek, #236 and Appomattox River, #270) were each represented by one specimen; the third site (Deep Creek, #269) yielded 17. Habitat characteristics in common among the sites included: slow flow; non-vegetated bottom; substrate mostly of sand/pea gravel but with some cobble; and clear water. Specific conductance was relatively high (112-122 µs/cm).

Notropis bifrenatus, Bridle Shiner: This petite cyprinid was found at only two sites, both in the middle system (Amelia County). Four specimens were collected in South Buckskin Creek (Co. Rt. 640; site 205) and one in North Branch Nibbs Creek (Co. Rt. 687; site 206); both collections were made on April 8. All five specimens were identified by Jenkins as documented by his and/or our notes, but both collections were later discarded. Habitat at the two streams was similar: mean width (3-3.7 m) and depth (15-46 cm); slow stream flow; water turbid; specific conductance, 75-78 µs/cm; pH 6.7-7.1; total hardness, 34-51 ppm; total alkalinity, 51-68 ppm); and water temperature (17.9-18.4° C). The sites differed considerably with respect to cover and substrate. Fish cover at Buckskin Creek was rated fair (brush and abundant macrophytes along the shoreline) whereas that at Nibbs Creek was poor (little brush and no macrophytes – basically a sand bar). The substrate at Buckskin Creek was soft mud; that at Nibbs Creek was mostly sand and silt with mud. Both sites had been impacted by watershed disturbances. There had been some highway construction and forest clearing at Buckskin Creek. The Nibbs Creek site had a pasture with agricultural field (row crop) along the sample site. Bridle Shiner is listed as a Species of Greatest Conservation Need (Tier I) in the Virginia Wildlife Action Plan (VDGIF, 2014).

Notropis procne, Swallowtail Shiner: This shiner was collected at 20 sites scattered over the drainage. It was uncommon with generally <10 specimens/site. Notable exceptions were Deep Creek (site 269) and Woody Creek (site 234), with counts of 89 and 121, respectively. These high counts are probably attributable to sampling method (rotenone) and survey length. Habitat characteristics in common included: slow stream flow, macrophytes absent, water clear, pH 7.2, and substrate mostly sand with some gravel/cobble/bedrock at one site.

Notropis volucellus, Mimic Shiner: Our records of the Mimic Shiner are the first for the Appomattox system. Our field notes indicate that Mimic Shiner was identified from preserved specimens (and thus, probably identified at Roanoke College), but do not state that the specimens were definitely identified at Roanoke College. Jenkins (pers. comm.) vaguely remembers identifying Mimic Shiner from at least one Appomattox collection. Unfortunately, the specimens were discarded.

Mimic Shiner was rare and limited in distribution; 10 specimens total were collected at two sites, both in the upper portion of the system: South Fork Spring Creek (#227) in Prince Edward County and Flat Creek (#236) in Nottoway County. Habitat differed between sites. Spring Creek was swift-flowing over sand/gravel/cobble and had good cover; it was turbid at the time sampled. Flat Creek was slow-flowing over sand and cover was poor; water was clear. pH was comparable (7.0 and 7.2). Other water quality parameters varied slightly. Each site had a diverse fish fauna: (Spring Creek, 19 species; Flat Creek, 21 species). *Notropis volucellus* probably is native to the Appomattox system. It typically occurs in medium-size streams and at least small rivers north and south of the Appomattox (Jenkins & Burkhead, 1994). Its distributional status in the Appomattox should be reconsidered after the system is well surveyed.

Rhinichthys atratulus, Blacknose Dace: Blacknose Dace was found at 29 sites, almost all of which were in the upper half of the system. It was generally uncommon (<10 collected/site), but there were a few notable exceptions with counts of >50 fish/site (one site produced 240 Blacknose Dace). Habitat characteristics at the four sites with the higher numbers of Blacknose Dace were: relatively small stream (mean width, 1.8-2.4

m; mean depth, 15-46 cm), slow to moderate flow, macrophytes absent, fish cover fair or good, pH 7.0-7.2, and substrate generally sand/gravel (some bedrock at one site). However, there were other sites with these same habitat characteristics which yielded only a few dace.

Rhinichthys cataractae, Longnose Dace: Longnose Dace was found at only five sites, all of which were in the extreme upper portion of the system (Appomattox and Prince Edward counties). The species was rare (21 fish), nine being the maximum number collected at any site. Longnose Dace was always found associated with Blacknose Dace, but the former was generally less abundant. Habitat at these five sites was mostly riffle/run over substrate of sand, gravel, cobble, and bedrock. The pH ranged from 7.1-7.4. There was almost complete forest canopy at each site. Field notes for some sites state that the stream looked like a mountain trout stream! Water clarity was clear at all but one site which was slightly turbid on the date of our sample. Apparently there was some major watershed disturbance upstream which involved destruction of the forest canopy, as inferred from the relatively high water temperature (26.5° C on July 9) compared with the water temperatures at three other sites (20° C on August 13-14).

Semotilus atromaculatus, Creek Chub: Creek Chub was fairly common and widely distributed in the system. It was always associated with Bluehead Chub but was seldom the numerically dominant chub (only 5 of the 37 syntopic sites). Of these five sites, Creek Chub was considerably more abundant at only one, where its dominance can be attributed to a much larger number of small (possibly YOY) fish. Creek Chubs ranged from 3-6 inches TL. The only habitat characteristics in common for the three sites yielding the greatest number of creek chubs were: relatively small stream (mean width, 1.8-3.7 m; mean depth, 15-46 cm), slightly alkaline (pH range, 7.1-7.2), and non-vegetated stream bottom.

Semotilus corporalis, Fallfish: The Fallfish was collected at 26 sites scattered in the upper two-thirds of the system. It was generally not common, with usually <10 specimens collected/site. Notable exceptions were Harris Creek (site 260), Vaughn's Creek (site 261), and Sayler's Creek (site 262), which collectively yielded 53.8% of the total specimens. Habitat characteristics at these three sites were: relatively small stream (mean width, 3-4.6 m; mean depth, 15-46 cm), slow to moderate flow, substrate of silt/sand/pea gravel/boulders, fish cover generally fair, and pH 6.9-7.1. Two of the sites were very silty, suggesting Fallfish are turbidity-tolerant. Fallfish in the samples ranged from 3-9 inches TL.

Family Catostomidae – Suckers

Erimyzon oblongus, Creek Chubsucker: We collected Creek Chubsuckers at 38 sites widely scattered in the entire system and which varied considerably in habitat characteristics. Where collected, it was relatively uncommon with <10 specimens at almost all sites with the exception of Neal's Creek (site 208) which yielded 98 specimens. An explanation for the high count was the abundance of juveniles including 45 specimens of the 0-3-inch class and 26 of the 4-inch class.

Hypentelium nigricans, Northern Hog Sucker: All but two of 13 collection sites for this species were located in the upper system. Both outliers were in the lower portion of the system (Deep Creek). The species was uncommon; fewer than five specimens were collected at almost all sites. One site (Rocky Run, #253) yielded 12 specimens; habitat there was riffle/run with pools to depth 0.8 m. The specimens were 3-10 inches TL.

Moxostoma cervinum, Blacktip Jumprock: The Blacktip Jumprock was collected at only one site (Neal's Creek, #208), which is in the central portion of the system (Amelia County), and represents the first record for the Appomattox system. Identification of the species was confirmed by Jenkins. Blacktip Jumprock is known in Virginia from the Chowan and Roanoke drainages (where it is native) and the James and New drainages (where it is believed introduced) (Jenkins & Burkhead, 1994). The four specimens that we collected included three of the 0-3-inch class and one of the 4-inch class, indicating natural reproduction. Habitat characteristics at the Neal's Creek site included: relatively small stream (mean width and depth of 2.4 m and 15 cm, respectively) with pools to depth 1 m (beaver pond upstream of the site); slow flow; non-vegetated bottom; substrate of sand/gravel/cobble; excellent cover; water slightly turbid; pH 7.0; and complete forest cover. Water temperature was 13.0° C (April 9).

Thoburnia rhothoeca, Torrent Sucker: Represented by 713 specimens collected at 34 sites, this was the most abundant catostomid, occurring commonly in the upper half of the system, sparsely in the mid-section and not found in the lower. Where encountered, generally <10 specimens were collected/site with the following notable exceptions: 217 fish at Rocky Run (site 253); 65 at Little Guinea Creek (site 251); 56 at Falling Creek (site 224); and 52 at Harris Creek (site 260). Habitat

characteristics at these sites were generally riffle/run with pools to 1 m; relatively small (mean width 1.5-3.7 m) and shallow (mean depth 15-30 cm); slow to moderate flow; substrate of sand/gravel/cobble with considerable silt at some sites; water clear; and pH 6.9-7.4. Two of these four sites were very silty. The suckers were 3-6 inches TL.

Family Ictaluridae – Bullhead Catfishes

Ameiurus natalis, Yellow Bullhead: The Yellow Bullhead was collected at 17 sites widely scattered over the system, but was rare with generally only 1-2 specimens collected/site. Specimens ranged from 3-12 inches TL; most were <9 inches TL. The yellow bullhead was found with brown bullhead at five of the 17 sites. Habitat characteristics varied considerably among the sites.

Ameiurus nebulosus, Brown Bullhead: The Brown Bullhead was also found widely scattered over the system and rare, with generally only one specimen collected/site. Specimens ranged from 3-9 inches TL, with most <6 inches. As with Yellow Bullhead, habitat characteristics varied considerably among the sites.

Ictalurus punctatus, Channel Catfish: This introduced species was represented by four fish found at two sites, including the Appomattox mainstem (#270) and Deep Creek (#269), a major tributary. Channel Catfish have been extensively stocked in Lake Chesdin, where the species is now common. The paucity of records in this survey is undoubtedly due to the species' habitat preference for lakes and medium and large rivers. Most of the streams surveyed in this study are small tributaries. Since the Channel Catfish stockings in Lake Chesdin began in the 1970s, it is apparent that the species will not move into small tributaries. Two adults (15 and 16 inches TL) were found; the other two were YOY, showing some natural reproduction in the mainstem and major tributaries.

Noturus insignis, Margined Madtom: This was the most abundant ictularid and one of the most abundant species in the collection. A total of 621 specimens was taken from 43 sites, which were widely scattered over the system. Generally <10 specimens were collected at each site but frequently 20-30 specimens were found. Streams which yielded the highest number of Margined Madtoms were Little Guinea Creek (site 251) and Deep Creek (site 269) with counts of 89 and 193, respectively. These had riffle/run habitat and pools to 1 m deep. Sampling method (rotenone) and survey length undoubtedly influenced the high counts, and presence of a forested riparian zone at each site may have contributed also by improving the insect forage base upon which madtoms depend.

Family Esocidae – Pikes

Esox niger, Chain Pickerel: This was the only esocid collected. It was widely distributed in the system but never common. Specimens ranged from 3-12 inches TL, showing some recruitment as well as the presence of a limited sport fishery.

Interestingly, and contrary to most literature (e.g., Scott & Crossman, 1973; Hastings, 1984; Jenkins & Burkhead, 1994), the abundance of Chain Pickerel was not directly related to aquatic macrophytes. Of the four sites where pickerel were most common, aquatic macrophytes were absent at two, fairly common at one and abundant at one. At another site with abundant macrophytes, only one pickerel was collected. However, the presence of Chain Pickerel does seem to be related to the amount of fish cover. Of the 23 sites where pickerel were found, fish cover was rated fair to excellent at 18, but poor at only five. Other habitat characteristics which seem to be favored by Chain Pickerel include a moderate stream flow and slightly acidic to neutral pH (6.5-7.0).

Chain Pickerel is the only esocid native to the Appomattox system. The apparent absence of its close relative (Redfin Pickerel, *E. americanus*) in the lower Appomattox is enigmatic considering its distribution in drainages north and south of the James drainage (Jenkins & Burkhead, 1994).

Family Aphredoderidae – Pirate Perches

Aphredoderus sayanus, Pirate Perch: This species was collected at 52 sites widely scattered over the system, but it was relatively uncommon with <5 specimens collected at most sites. Habitat varied considerably.

Family Poecidiidae – Livebearers

Gambusia holbrooki, Eastern Mosquitofish: This livebearer was very rare, with only 19 fish collected at six sites. It was most common at sites with abundant aquatic macrophytes (preferred habitat) but was also found at sites lacking such vegetation, the latter captures probably representing waifs from vegetated areas.

Family Centrarchidae – Sunfishes

Acantharchus pomotis, Mud Sunfish: Another rare species in the survey, 11 Mud Sunfish were found at

seven sites, all clustered in the lower third of the system (Amelia County) excepting one site (Rice Creek, #228) in the upper portion (Nottoway County). Habitat characteristics were fairly consistent across sites: stream size (mean width typically <2.4 m); stream flow (generally slow); fish cover (fair to excellent); water clarity (clear); and pH (acidic, 6.0–6.7). Most of the Mud Sunfish were of the 0–3-inch class, with a few specimens up to 6 inches TL, indicating a limited sport fishery potential. Mud Sunfish is listed as a Species of Greatest Conservation Need (Tier IV) in the Virginia Wildlife Action Plan (VDGIF, 2014)

Centrarchus macropterus, Flier: Flier was another very uncommon centrarchid, with 12 specimens collected from eight sites scattered across the lower two-thirds of the system. Habitat characteristics in common included: stream size (mean width was generally 1.8 m); stream flow (slow); and aquatic vegetation (absent or very sparse). The pH was acidic to slightly alkaline (range, 6.2-7.2). Specimens ranged from 3-7 inches TL, indicating a limited sport fishery potential.

Enneacanthus gloriosus, Bluespotted Sunfish: Bluespotted Sunfish was relatively uncommon; it was found at 12 sites, generally with <5 fish at each site. The species was found only in the lower two-thirds of the drainage, suggesting restriction to that area. Habitat characteristics varied considerably for most parameters. Fish cover including aquatic macrophytes varied greatly between sites and was often scant or absent. Cover was rated poor at five sites, fair at three, good at two, and excellent at two, whereas macrophytes were absent at eight sites, sparse at two, fairly common at one, and abundant at one. Even at the two sites yielding the most Bluespotted Sunfish (eight specimens each), habitat was considerably different (i.e., vegetation was abundant vs. absent; fish cover was excellent vs. poor; water clarity was dark vs. clear. The only habitat parameter that was fairly consistent among the 12 collection sites was stream flow, which we rated slow at 10 sites and moderate at two.

Lepomis auritus, Redbreast Sunfish: This native to the Atlantic Slope drainages was the most abundant centrarchid found in the survey. We collected 684 fish at 45 sites widely distributed over the entire system. The number collected/site varied greatly. The site yielding the most Redbreast Sunfish was #269 (Deep Creek), where we took 143 fish. The length-frequency distribution at this site was: 0-3-inch class, 86 fish; 4-inch class, 19; 5-inch class, 20; 6-inch class, 12; and 7-inch class, 6. This suggests excellent recruitment of the 1987 year class, with growth to 4 or 5 inches by Age-1 and to 6 or 7 inches by Age-2 or 3. The presence of harvestable-size fish shows that a sport fishery for Redbreast existed in these tributary streams.

Lepomis gibbosus, Pumpkinseed: Pumpkinseed was the third most abundant sunfish collected in the survey; 127 fish were taken from 35 sites scattered over the system wherein habitat varied considerably. The species was never common at any one site, with <10 fish collected/site at all but two sites. The two higher counts were due to a proliferation of YOY in the sample.

Lepomis gulosus, Warmouth: We collected Warmouth at 17 sites scattered over the entire system but concentrated in the middle portion. It was uncommon, with the maximum number collected at any individual site being five. The over-whelming majority of Warmouth were YOY. Only two harvestable-size fish were found (one each 6-inch and 7-inch classes), indicating that tributary streams function primary as a nursery area for Warmouth.

Lepomis macrochirus, Bluegill: We collected 406 Bluegill at 45 sites widely scattered over the system, making it the second most abundant sunfish in the survey. Generally <10 specimens were collected/site, but a notable exception was Deep Creek (site 269) where we took 89 Bluegill. YOY fish were collected at most sites, showing recruitment throughout the system in the sampled streams. Harvestable-size Bluegill (up to 7 inches) were collected at several sites, showing a sport fishery for this sunfish. Habitat characteristics of collection sites varied considerably. Bluegill is likely non-native to the James River basin.

Lepomis microlophus, Redear Sunfish: This introduced sunfish was very rare. We only collected three fish at two sites (Swift Creek, #194; and Deep Creek, #269), both relatively large tributaries. A major impoundment was located immediately upstream of the Swift Creek site, which could have been the source of the lone redear (3-inch fish) collected there. The Deep Creek sample yielded two 9-inch fish, indicating a very limited sport fishery for Redear Sunfish in the larger tributaries.

Micropterus dolomieu, Smallmouth Bass: We collected Smallmouth Bass (another introduced species) at eight sites, all but one concentrated in the upper system; the outlier was Deep Creek (site 269) in lower Amelia County. A total of 47 Smallmouth Bass was collected; these were up to 15 inches TL. Most specimens (76.5%) were taken from Rocky Run (site 253). Harvestable-size fish were collected in Deep Creek,

offering a sport fishery for Smallmouth Bass. Habitat at the collection sites was generally riffle/run with pools to depth 1 m; substrate was sand/gravel/cobble. Other habitat characteristics consistent at the sites included stream flow (generally slow), fish cover (generally fair to excellent) and water clarity (generally clear). The pH was slightly alkaline (7.1-7.4) at every site but one.

Micropterus punctulatus, Spotted Bass: We collected 52 specimens of Spotted Bass at six sites widely scattered over the system. The species was introduced by VDGIF into the Appomattox system in 1976-78 with the following stockings: 4,104 fish on 21 September 1976, Appomattox County; 3,000 on 20 July 1977, Prince Edward County; and 3,990 on 18 July 1978, Prince Edward County. All stockings were YOY fish, generally 2-3.5 inches. The purpose of the stocking was to establish another sport fish in medium-size Piedmont streams which offer little sport fishery.

Spotted Bass was the most abundant "black bass" in the survey. Specimens ranged from 3-13 inches TL. The collection of harvestable-size fish shows a sport fishery for Spotted Bass was established in these tributary streams. YOY fish were collected at four sites, indicating recruitment. Spotted Bass were found with Largemouth Bass at one site (Deep Creek, #269) and with Smallmouth Bass at two sites (Harris Creek, #260; and Vaughn's Creek, #261). Where co-existing with the other two *Micropterus* species, Spotted Bass was considerably the more abundant, outnumbering smallmouth bass 13 to 1 and 17 to 3 at those two sites, and largemouth bass 16 to 2. Not knowing the abundance of Smallmouth and Largemouth Bass in these streams prior to Spotted Bass introduction, one cannot say that Spotted Bass has displaced its congeners but it clearly appears that Spotted Bass are competing successfully in Appomattox tributaries. As with Smallmouth Bass, Spotted Bass were generally found in riffle/run habitat with pools to 1 m depth and a substrate of sand/gravel/cobble. Stream flow at every site was slow except for one which was moderate. We rated fish cover as fair at most sites but poor at two sites. The pH was very close to neutral, ranging from 6.9-7.3.

Micropterus salmoides, Largemouth Bass: Largemouth Bass, possibly non-native to the system, was found at nine sites scattered over the system but primarily in the lower portion. Only 14 specimens were taken which made it the least abundant "black bass" in the survey. Total lengths of the bass ranged from 3-9 inches with the 6-inch class being dominant. The presence of only subadult fish indicates that these tributary streams are basically nursery areas for Largemouth Bass. Habitat characteristics at the collection sites varied considerably but stream flow (generally moderate), fish cover (generally fair) and water clarity (generally clear) were remarkably consistent. The pH ranged from 6.3-7.2, with about an equal number of acidic and alkaline sites.

Pomoxis annularis, White Crappie: We collected three specimens (7-10 inches TL) at one site on the Appomattox River (#270), which was only the second record for White Crappie in the Appomattox system; the other was from Lake Chesdin. White Crappie is an introduced species to East Coast drainages.

Pomoxis nigromaculatus, Black Crappie: Black Crappie was very rare in the survey; only seven fish were collected at three sites, all of which had an impoundment a short distance upstream as likely sources of these occurrences. Specimens ranged from 3-10 inches TL, indicating at least a limited sport fishery in the small streams below impoundments.

Family Percidae – Perches

Etheostoma flabellare, Fantail Darter: This Atlantic Slope member of the fantail darter complex was the second most abundant darter. We collected 452 fish at 43 sites widely scattered in the system but mostly in the upper half. The species was more abundant at upper system sites. The highest number (94 specimens) was collected at Crane Creek (site 257), this being related to the sampling method (rotenone) and survey length (76 m). Habitat characteristics consistent at the sites with the highest concentration of Fantail Darters included: riffle/run over sand/gravel/cobble substrate, mean stream depth 15 cm, almost complete forest cover, and a very narrow pH range (7.0-7.2). Other habitat characteristics were variable.

Etheostoma fusiforme, Swamp Darter: We found this species at 13 sites scattered over most of the system, with only the extreme upper portion excluded. It was uncommon; we collected 35 specimens and generally took <5 specimens/site. It was most abundant at site 197 (unnamed tributary of Surline Branch) in Chesterfield County, where eight specimens were taken. Habitat characteristics at this site included: very small stream (mean width, 1.8 m; mean depth, 15 cm); primarily riffle (with cobble substrate) but some pools; moderate flow; no aquatic vegetation; cover fair; clear water; neutral pH; and complete forest canopy.

Etheostoma longimanum, Longfin Darter: Another rare species in the survey, we collected 59 specimens at three sites, all in the extreme upper system. All but two

were taken at one site (South Fork Appomattox River, #252). Habitat characteristics at this site included: mean stream width and depth of 3.7 m and 15 cm; slow flow; excellent cover; clear water; specific conductance, 78 µs/cm; total hardness, 51 ppm; total alkalinity, 68 ppm; pH 7.2; and complete forest canopy. Our habitat notes for the site indicate the appearance of a mountain trout stream. The site yielded three other darters (Johnny, Stripeback, and Fantail), all of which were also abundant, indicating that it provides excellent habitat for upland darters. Water temperature at the site was relatively cool (23.0° C on July 9), due, at least in part, to the presence of a complete forest canopy. The other two sites harboring Longfin Darters also had complete forest canopy and relatively cool water (20.0° C at each site on August 13 and 14).

Etheostoma nigrum, Johnny Darter (or, *E. olmstedi*, Tessellated Darter): This taxonomically complex species was the most common darter in the survey. We collected a total of 1,653 specimens at 64 sites widely scattered in the system, including >50 specimens at 12 sites and >100 specimens at three sites. Habitat characteristics consistent at the sites where the Johnny Darter was most common included: relatively small stream (mean width, 1.2-3.7 m); slow flow; substrate of sand/pea gravel; and slightly alkaline pH (7.0-7.2). The relationship between the closely related *E. nigrum* and *E. olmstedi* remains incompletely resolved in Atlantic Slope drainages (Jenkins & Burkhead, 1994) and many populations may represent hybrid amalgamations of the two, including in the Appomattox system.

Etheostoma vitreum, Glassy Darter: The Glassy Darter was found at 13 sites scattered over the upper two-thirds of the system but mostly in the upper portion. Generally <5 specimens were collected/site; notable outliers to this were sites 262 (Sayler's Creek, Prince Edward Co.) and 269 (Deep Creek, Amelia Co.), yielding 31 and 75 Glassy Darters, respectively. Other than substrate (sand/gravel/cobble), fish cover (fair), and pH (6.9-7.2), there was little similarity in habitat between these two sites which are at almost opposite ends of the system.

Perca flavescens, Yellow Perch: Yellow Perch was very rare; eight specimens were collected at three sites, including two sites (#189 and #194) on Swift Creek and one (#206) on the North Branch of Nibbs Creek. The presence of Yellow Perch in Swift Creek is not unexpected because it joins the Appomattox River below any mainstem dam and near the confluence with the James River where Yellow Perch are common. Its occurrence as a single specimen (7-inch class) in Nibbs Creek (above Lake Chesdin) shows that the species has not reproduced well above Brasfield Dam.

Percina notogramma, Stripeback Darter: This species was generally uncommon but was found at 30 sites widely scattered in the upper two-thirds of the system. Generally <5 specimens were encountered at each site; the higher counts were from sites 237 (Ellis Creek) and 252 (South Fork Appomattox River). Habitat characteristics at these sites were: riffle/run over substrate of sand/pea gravel/cobble, considerable fish cover, clear water, and slow flow. There was complete forest canopy at each site.

Percina peltata, Shield Darter: This darter was rare; we collected 29 specimens at four sites, two each in the upper and lower system. All but four specimens were taken at Deep Creek (site 269), the habitat characteristics of which were previously given.

DISCUSSION

We collected 17,210 fish representing 11 families, 35 genera, and 55 species. Species diversity per site ranged from 1 to 33, with 13 sites yielding at least 20 species. The richest sites were: Harris Creek (32 species, #260); Deep Creek (31 species, #269); Vaughn's Creek (26 species, #261), and Little Sayler's Creek (25 species, #262). The number of fish collected per site ranged from 1 to 1,273. Sites with the highest number of fish collected were: Rocky Run (1,273, #253), Deep Creek (993, #269), Poorhouse Creek (958, #258), and Harris Creek (793, #260).

Of the 55 species collected, forty-five (82%) are classified as native to the James River basin; one additional species (Warmouth) is regarded as native, but possibly introduced. Six species (Channel Catfish, Smallmouth Bass, Spotted Bass, Bluegill, White Crappie, and Redear Sunfish) are classified as introduced. Three additional species (Crescent Shiner, Blacktip Jumprock, and Largemouth Bass) are regarded as introduced, but possibly native in the James drainage. Crescent Shiner and Blacktip Jumprock are surely introduced in the Appomattox system. One species (Longfin Darter) is endemic to the James drainage. Stripeback Darter is endemic to the Atlantic slope from the Patuxent drainage in Maryland to the James drainage of Virginia (Jenkins & Burkhead, 1994). Three species are listed as Species of Greatest Conservation Need in Virginia – Bridle Shiner (Tier I), American Eel (Tier IV), and Mud Sunfish (Tier IV) (VDGIF, 2014).

Two new species records for the Appomattox system were encountered in this survey. These were

Mimic Shiner and Blacktip Jumprock. Two new site locations within the Appomattox system were documented for the Bridle Shiner, previously known from only seven sites. Expansion of the range for Crescent Shiner (previously known from only one site in the Appomattox system) was documented. We determined that Spotted Bass (introduced in 1976-78) has spread over the entire system and seems to have partially displaced both Largemouth and Smallmouth Bass as the dominant "black bass".

The catadromous American Eel was the only diadromous species collected. No shad or herring were found, showing the effectiveness of dams (notably Harvell and Brasfield) in halting fish migration farther upstream. Any shad or herring which might have been impounded upstream of these dams apparently did not survive up to the time of our study. Both Blueback Herring (*Alosa aestivalis*) and Alewife (*A. pseudoharengus*) inhabit small streams typical of this survey, but neither was documented despite considerable sampling during the period corresponding to spawning seasons.

Additional species known from tributaries of the Appomattox River but not collected in this survey are *Notropis rubellus* (Rosyface Shiner) and *N. hudsonius* (Spottail Shiner) (R. E. Jenkins, pers. comm.). Rosyface Shiner is known from seven sites extending from just above Lake Chesdin to the Appomattox headwaters (Jenkins & Burkhead, 1994). Habitat preference of this species is typical of many sites sampled in this survey. Absence of the Rosyface Shiner in our survey is inexplicable. Spottail Shiner is known from three sites (each represented by a single specimen) in the extreme lower portion of the Appomattox system (Jenkins & Burkhead, 1994). The species' abundance in the Coastal Plain is considered usually uncommon or common; it is found chiefly in large rivers and estuaries. With the focus of this survey on small to medium-size tributaries, it is understandable that the Spottail Shiner could have been missed.

Twenty additional species (representing 16 genera and nine families) have been reported from the mainstem of the Appomattox River (Jenkins & Burkhead, 1994) but were not collected in this survey due to our focus on tributaries (only two collections were made on the mainstem).

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LITERATURE CITED

EA Engineering, Science, and Technology, Inc. 2012. Appomattox River Instream Flow (IFIM) Study: George F. Brasfield Dam to Harvell Dam. Hunt Valley, MD. 39 pp.

Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold, & J. Wickham. 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States. Photographic Engineering & Remote Sensing 77: 858-864.

Hastings, R. W. 1984. The fishes of the Mullica River, a naturally acid river system of the New Jersey Pine Barrens. Bulletin of the New Jersey Academy of Science 29: 9-23.

Jenkins, R. E., & N. M. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, MD. 1079 pp.

Scott, W. B., & E. J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 996 pp.

VDGIF (Virginia Department of Game and Inland Fisheries). 2014. Wildlife Plans. www.bewildlife.org/wildlifeplan/. (Accessed March 2014).

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Freshwater Turtles in the Blackwater River Drainage in Southeastern Virginia

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ABSTRACT

We conducted a trapping survey of the freshwater turtles in the Blackwater River (Chowan drainage) located in southeastern Virginia during 1987 and 1988. We captured 565 turtles representing seven species at 57 sites. These were (in order of decreasing abundance): *Sternotherus odoratus*, *Kinosternon baurii*, *Chrysemys picta*, *Trachemys scripta scripta*, *Pseudemys rubriventris*, *Clemmys guttata*, and *Chelydra serpentina*. *Sternotherus odoratus*, *K. baurii*, and *C. picta* were relatively abundant and widely distributed throughout the drainage. C*helydra serpentina*, *P. rubriventris*, and *T. scripta* were relatively uncommon but the varying catchability of turtles was due to different trap types and their use prevented us from obtaining a clear understanding of their distribution patterns in the Blackwater River drainage. *Clemmys guttata* was found only in small tributaries. The environmental differences between the upper and lower Blackwater River allow comparative studies of how contrasting abiotic environments affect the biology of turtles and other animals that inhabit this riverine system.

Key words: Blackwater River, community ecology, turtle ecology, Virginia.

INTRODUCTION

Knowledge of freshwater turtle ecology has been based largely on numerous studies in lotic habitats, such as lakes, ponds, and ephemeral wetlands (Bury, 1979; Gibbons, 1990). However, relatively few thorough studies on the structure of riverine turtle communities have been published. Of these, most have focused on assemblages in the Mississippi River drainage (Moll, 1980; Anderson et al., 2002; Moll & Moll, 2004; Dreslik et al., 2005). In the southeastern United States, the structure of riverine turtle assemblages has been evaluated by mark-recapture studies in Georgia (Sterrett et. al., 2010) and Florida (Johnston et al., 2011). Short-term studies focusing on other topics such as distribution and toxicology have provided information on turtle assemblages in several eastern rivers. For example, composition of the turtle fauna in the South Fork of the Shenandoah River in Virginia was revealed during sampling to study the effects of mercury contamination (Bergeron et al., 2007). Mitchell & Pague (1984) reported the results of a faunal survey of amphibians and reptiles in southwestern Virginia that included a list of known species in the Clinch River. Turtle assemblages in rivers typically consist of primarily omnivorous species such as those in the genera *Chelydra*, *Chrysemys*, and *Trachemys*, as well as herbivores in the genus *Pseudemys*, along with a few strict carnivores (e.g., *Apalone* [Softshell Turtles]) in some areas (Moll & Moll, 2004).

The river systems in Virginia vary in size and most drain more than one physiographic region. The Blackwater River is relatively unique because its entire drainage occurs only in the Coastal Plain (Woodward & Hoffman, 1991). This region supports a diverse turtle

fauna, which is mostly known from studies conducted in ponds and lakes (Mitchell, 1994). We report herein the results of the first turtle trapping study to encompass the entire Blackwater River drainage. Our study was somewhat limited in scope because of the limitations of trap styles available to us at the time. However, we offer it as a baseline for future, more comprehensive, studies of the freshwater turtle assemblage in this Coastal Plain river. Norman (1989) summarized the capture results for 33 stations sampled in 1987. In this paper, we summarize the results from the full two-year study and provide distribution maps.

STUDY AREA

The Blackwater River is located in southeastern Virginia and flows south from its origin in Prince George County to the Nottoway River at the Virginia and North Carolina state line (Fig. 1), forming the Chowan River, a major tributary of the Albemarle-Pamlico Sound complex. In the vicinity of Isle of Wight County, the river changes direction (from southeasterly) and flows almost due south into North Carolina. The river is the boundary between Sussex and Surry counties, Southampton and Isle of Wight counties, and Southampton County and the City of Suffolk. The total length of the Blackwater River is 169 km and its watershed encompasses 1,917 km², most of which is agriculture, planted pine (mostly Loblolly Pine [*Pinus taeda*]), and secondary mixed hardwood forests (Fleming, 2012). The topography of the watershed is relatively flat to gently sloping terrain. Much of the riparian zone along the river is a heavily wooded floodplain wetland, especially in the upper reach. Dominant trees include Bald Cypress (*Taxodium distichum*), Tupelo Gum (*Nyssa sylvatica*), Water Hickory (*Carya aquatica*), Swamp Cottonwood (*Populus heterophylla*), Carolina Ash (*Fraxinus caroliniana*), Green Ash (*F. pennsylvanica*), Deciduous Holly (*Ilex decidua*), Green Hawthorn (*Crataegus viridis*), Red Maple (*Acer rubrum*), River Birch (*Betula nigra*), Overcup Oak (*Quercus lyrata*), Laurel Oak (*Q. laurifolia*), American Persimmon (*Diospyros virginiana*), and American Elm (*Ulmus americana*). Numerous debris dams, primarily from fallen trees, occur in the river from its origin in Prince George County to just above Franklin in Southampton County (MDN, pers. obs.). In this area, the forest canopy in the riparian zone usually covers and shades the entire river. Below Franklin, the river widens appreciably allowing exposure away from the forest canopy. In this lower section, the river has been channelized in three sections and occasionally cleared of snags for barge traffic to reach the city from Pamlico Sound. The Blackwater River is aptly named because the water is dark from tannic and other organic acids from decaying vegetation in the swamps.

Water quality in the Blackwater River is typical of Coastal Plain streams in Virginia. The water is somewhat acidic (pH generally 5.5-6.5) and relatively low in total hardness (generally 45-75 ppm). Total alkalinity is usually 40-70 ppm, specific conductance is 70-160 µSiemens, and dissolved oxygen is 2-4 ppm for most of the year with highs of 7-10 ppm during the winter months (Virginia Department of Game and Inland Fisheries, unpublished data).

MATERIALS AND METHODS

We selected 57 trap sites extending from the middle of Prince George County to below Franklin (Fig. 1). Twenty-eight of the stations were located on tributaries of the Blackwater River, 24 were on the mainstem, and five were located in millponds within the drainage. We conducted the survey during 6 June-1 November 1987 and 26 March-27 July 1988.

We captured most of the turtles in handmade traps (wire traps) made of one inch diameter poultry wire (76 x 30 x 30 cm) following the design created by Iverson (1979). Each end of the box trap had a funnel opening that measured about 3-4 cm high and 15-20 cm wide. The funnels were flexible to allow turtles to enter but they also restricted exit. We also used commercial trap nets (fyke nets) made of one inch (2.5 cm) mesh nylon netting commonly used in fish population sampling. Nets had two rectangular frames (approximately 90 x 150 cm) on the anterior end and 6-8 circular hoops of diminishing diameters (approximately 50-90 cm), one anterior funnel, and a lead about 10 m long and 0.76 m tall. These traps were set perpendicular to the shoreline with the distal end of the lead attached to vegetation. Turtles moving near the river's edge were directed into the trap by the lead.

We sampled most stations (49) exclusively with chicken wire funnel traps, six stations with trap nets, and one station with chicken wire traps and trap nets (Table 1). We captured turtles at one station only by hand. Sampling effort per station ranged from 5 to 152 trap days (mean = 46.2 d). Traps were not baited. Each was set in the water with the top above the surface to prevent drowning of captured turtles. Traps were generally checked twice per week when all turtles were removed and identified.

Kinosternon baurii (Striped Mud Turtle) was only recently determined to occur in southeastern Virginia (Lamb & Lovich, 1990), having been overlooked historically due to similarities with *K. subrubrum* (Eastern Mud Turtle). Although shell shape was first

described as being diagnostic (Lamb & Lovich, 1990), we identified them by the presence of a light bar between the eye and nostril on each side (Mitchell, 1994). Nomenclature and common names follow Crother (2012) for turtles and Weakley et al. (2012) for plants.

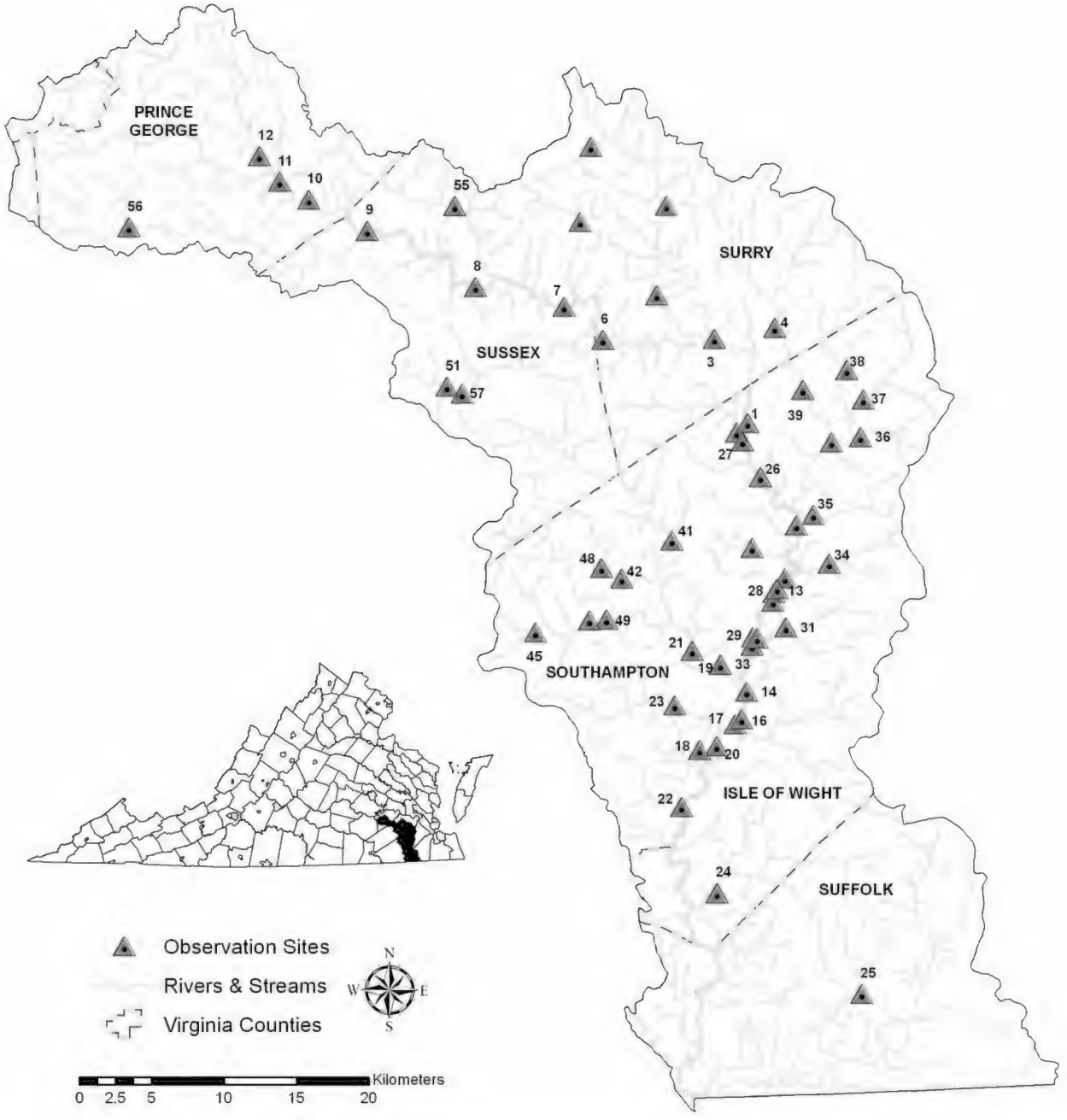

Fig. 1. Location of turtle sampling stations in the Blackwater River drainage, 1987-1988.

Table 1. Location (county), habitat, trap type, and trapping effort at the 57 stations included in the Blackwater River drainage study, 1987-1988.

Station	County	Habitat	Trap Type	No. Trap Days
1	Southampton	mainstem	wire trap	30
2	Isle of Wight	tributary	wire trap	30
3	Surry	mainstem	wire trap	40
4	Surry	tributary	wire trap	20
5	Surry	tributary	wire trap	16
6	Surry	mainstem	wire trap	93
7	Surry-Sussex	mainstem	wire trap	35
8	Surry-Sussex	mainstem	wire trap	28
9	Surry-Sussex	mainstem	wire trap	35
10	Prince George	mainstem	wire trap	32
11	Prince George	mainstem	wire trap	28
12	Prince George	mainstem	wire trap	28
13	Isle of Wight	mainstem	wire trap	28
14	Isle of Wight	mainstem	wire trap	21
15	Isle of Wight	mainstem	trap net	5
16	Isle of Wight	mainstem	trap net	5
17	Isle of Wight	mainstem	trap net	5
18	Southampton	mainstem	trap net	5
19	Southampton	tributary	wire trap	28
20	Isle of Wight	mainstem	wire trap	29
21	Southampton	tributary	wire trap	34
22	Southampton	mainstem	wire trap	17
23	Southampton	millpond	wire trap	12
24	Isle of Wight	millpond	wire trap	72
25	Suffolk	tributary	wire trap	8
26	Isle of Wight	mainstem	wire trap	59
			trap net	37
27	Isle of Wight	mainstem	wire trap	46
28	Isle of Wight	mainstem	wire trap	74
29	Isle of Wight	mainstem	wire trap	18
30	Isle of Wight	tributary	wire trap	45
31	Isle of Wight	tributary	wire trap	36
32	Isle of Wight	mainstem	trap net	32
33	Isle of Wight	mainstem	trap net	37
34	Isle of Wight	tributary	wire trap	42
35	Isle of Wight	tributary	wire trap	54
36	Isle of Wight	tributary	wire trap	92
37	Isle of Wight	tributary	wire trap	132
38	Isle of Wight	tributary	wire trap	137
39	Isle of Wight	tributary	wire trap	152
40	Southampton	tributary	wire trap	44
41	Southampton	tributary	wire trap	24
42	Southampton	tributary	wire trap	64
43	Southampton	tributary	wire trap	24
44	Southampton	tributary	wire trap	29
45	Southampton	tributary	wire trap	5
46	Southampton	tributary	wire trap	28
47	Southampton	tributary	wire trap	54
48	Southampton	millpond	wire trap	90
49	Southampton	tributary	wire trap	117
50	Isle of Wight	mainstem	hand	0
51	Sussex	tributary	wire trap	48
52	Surry	tributary	wire trap	38
53	Surry	tributary	wire trap	102
54	Surry	tributary	wire trap	48
55	Surry	tributary	wire trap	72
56	Prince George	millpond	wire trap	103
57	Sussex	millpond	wire trap	22

RESULTS

We captured a total of 565 turtles representing three families and seven species. In order of decreasing abundance, these included: *Sternotherus odoratus* (Eastern Musk Turtle), 354 individuals (62.7%); *K. baurii*, 96 individuals (17.0%); *Chrysemys picta picta* (Eastern Painted Turtle), 90 individuals (15.9%); *Trachemys scripta scripta* (Yellow-bellied Slider), 10 individuals (1.8%); *Pseudemys rubriventris* (Northern Red-bellied Cooter) and *Clemmys guttata* (Spotted Turtle), six individuals each (1.1%); and *Chelydra serpentina* (Snapping Turtle), three individuals (0.5%). We captured three species (*S. odoratus*, *K. baurii*, *C. picta*) throughout the Blackwater River drainage (Figs. 2-4), whereas the remaining four species were captured at four or fewer stations (Figs. 5-6). Relatively few *C. guttata*, *C. serpentina*, *P. rubriventris*, and *T. scripta* were captured in this study, although all were captured in both trap types. Capture success is summarized in Table 2.

Species diversity at individual stations was limited. We found one species at 19 stations, two species at 19 stations, three species at 15 stations, one site with four species, and five species at one station. Species associations included *S. odoratus* and *K. baurii* or *S. odoratus* and *C. picta* at 23 stations each; *K. baurii* and *C. picta* at 19 stations; and *S. odoratus*, *C. picta*, and *K. baurii* at 17 stations. We captured turtles as early as March 26 and as late as November 1. Capture rate (#turtles/trap-day) varied considerably among stations and seasonally. We found no discernible seasonal peak in numbers captured per unit effort but the capture rate for all species declined appreciably after August.

We caught turtles at all but two stations (#46, Warwick Branch and #44, Horsepen Branch, a tributary of Warwick Branch). Stations with the most turtles collected (n = 48 each) were #6 (Blackwater River mainstem at Rt. 31) and #48 (Kello Millpond on Lightwood Swamp). Other stations with a high number of turtles captured were 36 individuals at #3 (Blackwater River mainstem at Rt. 617), 34 at #24 (Lee's Millpond), and 28 at #21 (Seacock Swamp at Rt. 623).

Overall mean capture rate for all species (using only the effort for the wire traps) combined was 0.219 per trap-day. The highest capture rate (1.08 turtles/trap-day) for any station was #23 (Wade Pond on Black Creek). In general, stations with higher catch rates were those on the river mainstem or in millponds. Of the 11 stations with a catch rate >0.5 turtles/trap-day, only two were on tributaries.

We trapped *Sternotherus odoratus* at more stations in this survey (40 of 57) than any other species. It is widely distributed throughout the drainage (Fig. 2). They were captured as early as April 3 and as late as October 18. Average number of *S. odoratus* captured per station was 8.9, although as many as 38 individuals were taken at a single location. Overall capture rate was 0.140 per trap-day. Of the 10 stations with the highest catch rates ($\geq$0.3 turtles/trap-day), eight were either on the mainstem or millponds. The two tributary stations with catch rates exceeding 0.3 per trap-day were both in Seacock Swamp, a major tributary.

We trapped *Kinosternon baurii* at 31 stations indicating that this species is widely distributed throughout the drainage (Fig. 3). The number of *K. baurii* per station ranged from one to nine and averaged 3.1. Overall capture rate was 0.036 per trap-day. These turtles were caught as early as April 3 and as late as October 4, although most were collected in June and July.

We trapped *Chrysemys picta* at 30 stations and numbers ranged from one to ten (mean = 1.6) per station. Overall capture rate was 0.035 per trap-day. It was also widely distributed throughout the drainage (Fig. 4). All captures were between April 5 and October 18, with most taken in June and July.

Table 2. Distribution of capture success by method for freshwater turtles at 57 sites in the Blackwater River drainage.

Species	#Sites	Wire trap	Trap net	Hand	Total
Sternotherus odoratus	40	344	10	0	354
Kinosternon baurii	31	89	5	2	96
Chrysemys picta	30	87	3	0	90
Trachemys scripta	2	10	0	0	10
Pseudemys rubriventris	4	1	5	0	6
Clemmys guttata	4	6	0	0	6
Chelydra serpentina	3	2	1	0	3
Number of trap days		2463	126		
Total	57	539	24	2	565

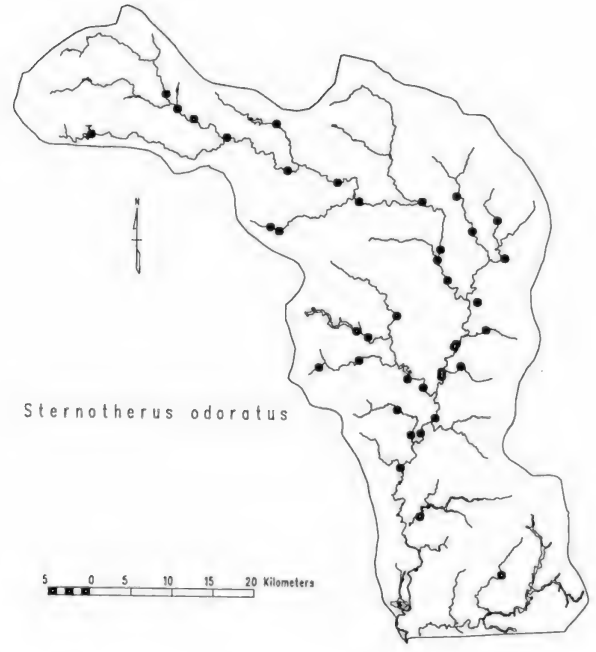

Fig. 2. Distribution of *Sternotherus odoratus* (Eastern Musk Turtle) captures in the Blackwater River, 1987-1988.

Fig. 3. Distribution of *Kinosternon baurii* (Striped Mud Turtle) captures in the Blackwater River, 1987-1988.

Fig. 4. Distribution of *Chrysemys picta* (Eastern Painted Turtle) captures in the Blackwater River, 1987-1988.

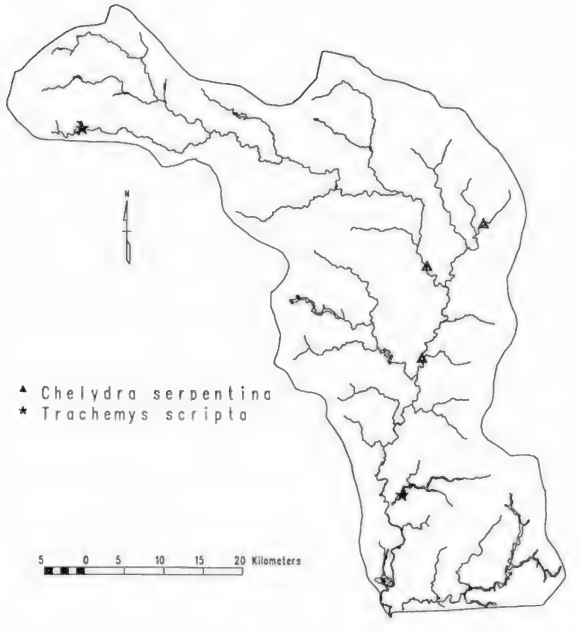

Fig. 5. Distribution of *Chelydra serpentina* (Snapping Turtle) and *Trachemys scripta* (Yellow-bellied Slider) captures in the Blackwater River, 1987-1988.

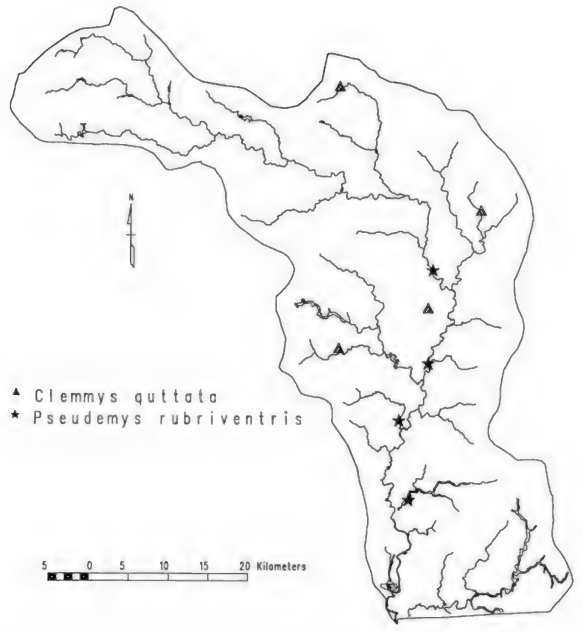

Fig. 6. Distribution of *Clemmys guttata* (Spotted Turtle) and *Pseudemys rubriventris* (Northern Red-bellied Cooter) captures in the Blackwater River, 1987-1988.

We cannot ascertain the distribution or relative abundance of the remaining four species in the Blackwater River, its tributaries, and associated millponds (Fig. 5) because they were captured in low numbers. We trapped *Trachemys scripta* at only two stations, both millponds. Overall capture rate was 0.004 per trap-day. Capture rates for the remaining three species were $\leq$ 0.002 per trap-day. We captured six *P. rubriventris* at four stations. One station was a millpond and the other three were on the mainstem. We also captured *C. guttata* at four stations, all of which were tributary streams. We trapped three *C. serpentina*, two in the mainstem and one in a tributary.

DISCUSSION

Trap design and type used to capture freshwater turtles in lotic and lentic habitats greatly influences the species and number of individuals captured (Ream & Ream, 1966; Plummer, 1979). Chicken wire traps, baited or unbaited, are especially effective for kinosternids (*Kinosternon* and *Sternotherus*) because the ramp provides a continuation of the bottom substrate contour. These turtles follow the ramp to the opening and once trapped are less likely to escape compared to other species (JCM, pers. obs.). These traps also capture large numbers of *C. picta* when bait, such as sardines, is used (Mitchell, 1988). *Clemmys guttata* can be trapped with chicken wire traps but they inhabit wetlands often too shallow to trap and rarely venture into deeper water (Mitchell, 1994). The number of *C. serpentina*, *P. rubriventris*, and *T. scripta* captured by chicken wire traps is usually less than that captured by conventional turtle hoop traps and fyke nets, especially when there is no bait (Vogt, 1980). The capture of so few individuals of these three species can be attributed to the size and type of trap used and lack of bait. In addition, *P. rubriventris*, and *T. scripta* are herbivorous as adults (Ernst & Lovich, 2009) and seldom caught with fish bait (JCM, pers. obs.). Thus, our understanding of the distribution of the freshwater turtles in the Blackwater River drainage is limited to three of the seven species captured. We are unable to describe the structure of the turtle community precisely because of the low captures of these four species.

The three species for which we have adequate data (*C. picta*, *K. baurii*, *S. odoratus*) occur throughout the entire drainage in the river mainstem, its tributaries, and associated millponds. The numbers caught suggest that their populations were healthy in the 1980s in the Blackwater River.

Occurrences of all seven of the species we captured were expected because of the early distribution maps assembled from museum specimens and miscellaneous observations reported to the Virginia Herpetological Society by Tobey (1985). This document was the first to illustrate the distributions of all of Virginia's amphibians and reptiles. It and the turtle study by Mitchell (1988) provided confidence that our trapping methods, particularly the chicken wire traps, would capture most, if not all, of the species known to occur in the Blackwater River. Thus, perhaps with two exceptions, we are confident that the composition of the turtle fauna in this exclusively Coastal Plain river is now well known.

Coastal Plain Cooters (*Pseudemys concinna floridana*) occur in southeastern Virginia (Mitchell & Reay, 1999), but unlike its sister subspecies *P. c. concinna* (Eastern River Cooter) that occurs primarily in rivers in the Piedmont, this turtle has only been documented from ponds and lakes (Mitchell, 1994). *Pseudemys c. floridana* is well known to inhabit other rivers south of Virginia (Ernst & Lovich, 2009), suggesting that this species may eventually be documented in the Blackwater River.

We initially thought that many of the mud turtles captured were *K. subrubrum* (all were reported as such in Norman, 1989) and their locations were plotted on the map in Mitchell & Reay (1999). However, reexamination of these specimens, after clarification of

the occurrence of *K. baurii* in Virginia (Lamb & Lovich, 1990), indicated that they were in fact all *K. baurii*. We are confident our identification is correct due to the presence of light bars on the snouts of these specimens (a diagnostic character for the species). *Kinosternon subrubrum* almost certainly occurs in the Blackwater River drainage, especially in its preferred marsh and pond habitats, because it is widespread in the Coastal Plain (Mitchell, 1994; Mitchell & Reay, 1999). Future studies of the freshwater turtles in this area should seek to clarify the relative distributions of these two mud turtles.

Coastal Plain rivers in the southeastern United States support a diverse assemblage of freshwater turtles (Buhlmann & Gibbons, 1997). The Blackwater River is an example of an aquatic ecosystem that differs abiotically and biotically along its length (MDN, pers. obs.). The closed canopy over much of the upper reach of this river and the debris dams above Franklin undoubtedly create a different environment than that found below Franklin. Water temperature may influence seasonal activity patterns and open, sunny sites along the river needed for successful nesting may be scarce. These factors may in turn influence turtle life histories in the upper reach compared to contrasting temperatures and nesting success in the lower reach. The structure of other rivers in the Southeast also provides contrasting habitats for turtles. For example, the Santa Fe River in northern Florida is tannic and divided by a 5 km section where the river flows underground (Johnston et al., 2012). The upper Santa Fe River is narrower and has a more closed canopy than the lower portion of the river and the lower section is fed by a large number of springs that maintain stable water temperatures and water clarity (Johnston et al., 2011, 2012; Nico et al., 2012). Thus, environmental differences between the upper and lower Blackwater River provide abiotic environments that affect the biology of turtles and likely other animals such as macroinvertebrates (e.g., Smock et al., 1985, 1989) that inhabit blackwater stream systems.

ACKNOWLEDGEMENTS

We thank Richard Cowell and Ron Southwick for their help in the field. This study was partially supported by the Virginia Department of Game and Inland Fisheries (DGIF) while the senior author was employed there. DGIF also issued collecting permits to JCM. Voucher specimens were deposited in the National Museum of Natural History.

LITERATURE CITED

Anderson, R. V., M. L. Gutierrez, & M. A. Romano. 2002. Turtle habitat use in a reach of the upper Mississippi River. Journal of Freshwater Ecology 17: 171-177.

Bergeron C. M., J. Husak, W. A. Hopkins, J. M. Unrine, & C. S. Romanek. 2007. Influence of feeding ecology on blood mercury concentrations in four turtle species. Environmental Toxicology and Chemistry 26: 1733-1741.

Buhlmann, K. A., & J. W. Gibbons. 1997. Imperiled aquatic reptiles of the southeastern United States: historical review and current conservation status. Pp. 201-231 *In* G. W. Benz & D. E. Collins (eds.), Aquatic Fauna in Peril: The Southeastern Perspective. Special Publication No. 1, Southeast Aquatic Research Institute, Lenz Design & Communications, Decatur, GA.

Bury, R. B. 1979. Population ecology of freshwater turtles. Pp. 571-602 *In* M. Harless & H. Morlock (eds.), Turtles, Perspectives and Research. John Wiley & Sons, New York, NY.

Crother, B. I. (committee chair). 2012. Scientific and standard English and French names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Society for the Study of Amphibians and Reptiles, 7th edition, Herpetological Circular 39: 1-92.

Dreslik, M. J., A. R. Kuhns, & C. A. Phillips. 2005. Structure and composition of a southern Illinois freshwater turtle assemblage. Northeastern Naturalist 12: 173-186.

Ernst, C. H., & J. E. Lovich. 2009. Turtles of the United States and Canada. 2nd Edition, Johns Hopkins University Press, Baltimore, MD. 827 pp.

Fleming, G. P. 2012. The nature of the Virginia flora. Pp. 24-75 *In* A. S. Weakley, J. C. Ludwig, & J. F. Townsend. Flora of Virginia. B. Crowder (ed.). Botanical Institute of Texas Press, Fort Worth, TX.

Gibbons, J. W. 1990. Life History and Ecology of the Slider Turtle. Smithsonian Institution Press, Washington, DC. 368 pp.

Iverson, J. B. 1979. Another inexpensive turtle trap. Herpetological Review 10: 55.

Johnston, G. R., A. Lau, & Y. V. Kornilev. 2011. Composition of the turtle assemblage in a northern Florida blackwater stream. Florida Scientist 74: 126-133.

Johnston, G. R., E. Suarez, J. C. Mitchell, G. A. Shemitz, P. L. Butt, & M. W. Kaunert. 2012. Population ecology of the snapping turtle (*Chelydra serpentina osceola*) in a northern Florida river. Bulletin of the Florida Museum of Natural History 51: 243-256.

Lamb, T., & J. Lovich. 1990. Morphometric variation of the striped mud turtle (*Kinosternon baurii*) in the Carolinas and Virginia. Copeia 1990: 615-618.

Mitchell, J. C. 1988. Population ecology and life histories of the freshwater turtles *Chrysemys picta* and *Sternotherus odoratus* in an urban lake. Herpetological Monographs 2: 40-61.

Mitchell, J. C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington DC. 352 pp.

Mitchell, J. C., & C. A. Pague. 1984. Reptiles and amphibians of far southwestern Virginia: report on a biogeographical and ecological survey. Catesbeiana 4(2): 12-17.

Mitchell, J. C., & K. Reay. 1999. Atlas of Amphibians and Reptiles in Virginia. Special Publication Number 1, Virginia Department of Game and Inland Fisheries, Richmond, VA. 122 pp.

Moll, D., & E. O. Moll. 2004. The Ecology, Exploitation, and Conservation of River Turtles. Oxford University Press, New York, NY. 393 pp.

Moll, D. L. 1980. Dirty river turtles. Natural History Magazine 89(5): 42-49.

Nico, L. G., P. Butt, G. R. Johnston, H. L. Jelks, M. Kail, & S. J. Walsh. 2012. Discovery of South American suckermouth armored catfishes (Loricariidae, *Pterygolpichthys* spp.) in the Santa Fe River drainage, Suwannee River basin, USA. Bioinvasions Records 1: 179-200.

Norman, M. D. 1989. Preliminary survey of the freshwater turtles of the Blackwater River. Catesbeiana 9: 9-14.

Plummer, M. V. 1979. Collecting and marking. Pp. 45-60 *In* M. Harless & H. Morlock (eds.), Turtles, Perspectives and Research. John Wiley & Sons., New York, NY.

Ream, C., & R. Ream. 1966. The influence of sampling methods on the estimation of population structure in painted turtles. American Midland Naturalist 75: 325-338.

Smock, L. A., E. Gilinsky, & D. L. Stoneburner. 1985. Macroinvertebrate production in a southeastern United States blackwater stream. Ecology 66: 1491-1503.

Smock, L. A., C. M. Metzler, & J. E. Gladden. 1989. Role of debris dams in the structure and functioning of low-gradient headwater streams. Ecology 70: 764-775.

Sterrett, S. C., L. L. Smith, S. W. Golladay, S. H. Schweitzer, & J. C. Mearz. 2010. The conservation implications of riparian land use on river turtles. Animal Conservation 14: 38-46.

Tobey, F. J. 1985. Virginia's Amphibians and Reptiles, A Distributional Survey. Privately published for the Virginia Herpetological Society, Purcellville, VA. 114 pp.

Vogt, R. C. 1980. New methods for trapping aquatic turtles. Copeia 1980: 368-371.

Weakley, A. S., J. C. Ludwig, & J. F. Townsend. 2012. Flora of Virginia. B. Crowder (ed.), Foundation of the Flora of Virginia Project Inc., Botanical Institute of Texas Press, Fort Worth, TX. 1,554 pp.

Woodward, S. L., & R. L. Hoffman. 1991. The nature of Virginia. Pp. 23-47 *In* K. Terwilliger (coordinator), Virginia's Endangered Species, McDonald & Woodward Publishing Company, Blacksburg, VA.

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Amphibian and Reptile Communities in Hardwood Forest and Old Field Habitats in the Central Virginia Piedmont

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ABSTRACT

A 13-month drift fence study in two replicates of hardwood forest stands and two fields in early succession in the central Virginia Piedmont revealed that amphibian abundance is significantly reduced by removal of forest cover. Pitfall traps captured 12 species of frogs, nine salamanders, four lizards, and five snakes. Twenty-two species of amphibians were captured on the hardwood sites compared to 15 species on the old fields. Eight times as many amphibians were caught per trap day on both hardwood sites than in the combined old field sites. The total number of frogs captured on the hardwoods was higher than in the old fields, as was the total number of salamanders. Numbers of frogs and salamanders captured per trap day were significantly higher in the hardwood sites than in the old field sites. Seven species of small-bodied reptiles were caught in both habitat types. More lizard species were captured in the old fields, whereas more snakes were caught in the hardwoods. The number of individual reptiles captured per trap day was similar in both habitat types. Despite the fact that large portions of the Virginia Piedmont remained in agriculture following losses in the 18th century, reclaimed areas such as in private and state forests, state and national parks, and federal military bases have slowed amphibian declines in some of this landscape. Projected urban growth and continued timber harvest in the Virginia Piedmont may substantially reduce amphibian species richness in portions of this region leaving only generalist species.

Key words: Anura, clearcut, forest management, lizard, Piedmont, salamander, snake, Virginia.

INTRODUCTION

A basic tenant in ecology is that animal assemblages contain species distributed unequally within and among habitat types. Such variation is due to such factors as species distribution patterns, annual variation in weather, seasonal variation in environmental conditions such as moisture and pH, microhabitat structure, densities of predators and prey, and natural and anthropogenic changes in habitat structure (e.g., Adler, 1988; Kirkland, 1990; Mitchell et al., 1997; Bellows et al., 2001; Brawn et al., 2001). Species richness (alpha diversity) of amphibian and reptile assemblages may be similar between habitats but the relative abundance of individual species varies (Magurran, 2004). More often than not, both species richness and their relative abundances vary within assemblages among different habitat types (e.g., Ross et al., 2000; Knapp et al., 2003; Goldstein et al., 2005). These relationships have been studied in Virginia for mammals (e.g., Pagels et al., 1992; Mitchell et al., 1997; Bellows et al., 1999, 2001; Bellows & Mitchell, 2000; Shively et al., 2006) and amphibians and reptiles (e.g., Buhlmann et al., 1994; Mitchell et al., 1997; Harpole & Haas, 1999; Mitchell et al., 2000; Burruss et al., 2011).

In 1989 and 1990, I conducted a study of terrestrial amphibians and small reptiles at four localities in northern Cumberland County, Virginia, in connection with a site evaluation for a proposed coal-fired power plant. The habitats in this area differed dramatically. Two of the study sites were hardwood forests with canopy cover, whereas two others had been clearcut and completely lacked canopy cover. In this paper, I report the results of a study comparing the structure of amphibian and squamate (lizard and snake) reptile assemblages in these two contrasting habitat types to ask if the magnitude of the differences between these two habitats in this area may have broader applications in the central Virginia Piedmont physiographic region.

STUDY SITES

I studied the herpetofaunas on four sites in Cumberland County, Virginia, from 7 September 1989 to 30 September 1990. The sites were selected to represent the most common habitats in this region that were not in active agriculture. Site locations were non-randomly selected for road access and visual representation of the habitat. Their locations were roughly along a line extending 3-6 km south of the town of Columbia in Goochland County (Fig. 1). The study sites included two separate mixed hardwood stands (designated as north [HW-N] and south [HW-S], both approximately 40+ yr in age) and two areas that had been previously clearcut (fields in early succession [= old fields], also north [OF-N] and south [OF-S]) that were 3 yr and 6 yr old, respectively. Descriptions of the study sites (Fig. 2) are derived from Pagels et al. (1992), Erdle (1997), and my own observations.

Hardwood stands - The most abundant tree species in HW-N were red maple (*Acer rubra*), shortleaf pine (*Pinus echinata*), tulip poplar (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), and white oak (*Quercus alba*). The sparse understory consisted primarily of dogwood (*Cornus virginianus*). Canopy cover averaged 86%. A tributary of Cobb Creek was located adjacent to this site. HW-S differed from HW-N in the relative abundance of trees and the composition of the herbaceous layer. Sweet gum (*Liquidambar styraciflua*) was the most abundant tree species, followed by tulip poplar, red maple, and white oak. Canopy cover was 75%. A tributary of Johnson's Creek was about 20 m away from this site.

Old fields - OF-N was characterized primarily by shrubs such as gooseberry (*Ribes* spp.) and blueberry (*Vaccinium* spp.) followed by forbs and vines. OF-S consisted primarily of forbs, such as horse weed (*Erigeron canadensis*), white thoroughwort (*Eupatorium album*), partridge berry (*Mitchella repens*), and partridge pea (*Chamaecrista fasciculata*) followed by vines and grasses. Numerous loblolly pine (*Pinus taeda*) trees had been planted in both sites (Fig. 2). Hardwood stumps occurred on both sites. There was no canopy cover. A very narrow, small seepage area that held water only during wet periods was located within 30–40 m of each site.

MATERIALS AND METHODS

I used a single pitfall-drift fence array (Campbell & Christman, 1982) in each of the four sites to capture terrestrial amphibians and reptiles. Each array consisted of three 8-m long strips of 60 cm high aluminum flashing set upright in an exploded Y-configuration with each arm located about 7–8 m from the open center of the sample site. A plastic 5-gallon (19-l) bucket was buried flush in the ground at the end of each arm; six pitfall traps in each array. Arrays were set at least 100 m from the nearest edge of the adjacent habitat. Traps contained a weak formalin solution, and were emptied at about two-week intervals. Use of funnel traps placed alongside the drift fences would have increased reptile captures, especially snakes (Vogt & Hine, 1982) but daily trap checks were cost prohibitive. The sampling technique in this study allowed me to effectively compare abundance and species composition of anurans, lizards, and small snakes between the two habitat types

Gender of the adults of each species and juvenile snakes was determined by examination of external morphology. Chi-square tests used herein include Yates correction for continuity following Zar (2009).

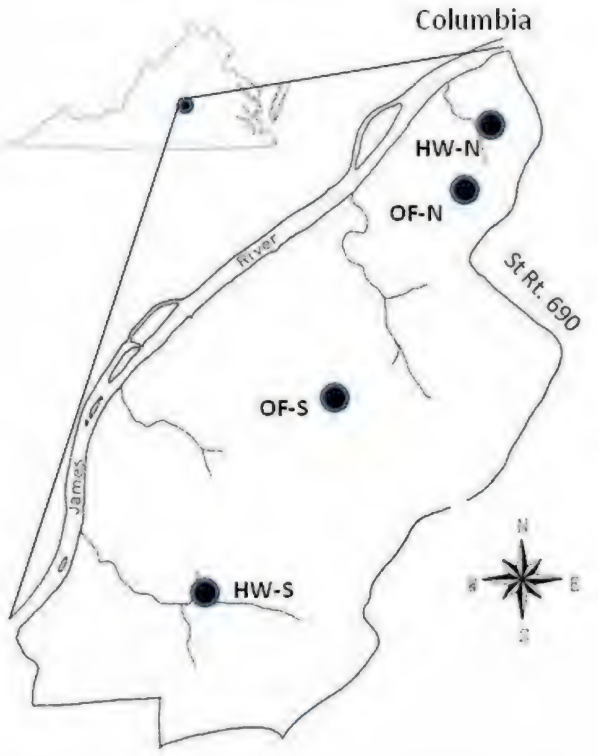

Fig. 1. Location of the five study sites in Cumberland County, Virginia. Abbreviations: HW-N = hardwoods north, HW-S = hardwoods south, OF-N = old field north, OF-S = old field south.

Fig. 2. Photographs of the four sampling sites in Cumberland County. Upper left: HW-N, upper right: HW-S, lower left: OF-N, lower right: OF-S. See text for site descriptions.

RESULTS

The drift fence arrays captured 958 individuals in the four study sites during the 13-month study, including 21 species of amphibians and nine species of reptiles (Table 1). Eight times more amphibians (854) were caught than reptiles (104). Seven times as many amphibians were caught per trap day on the hardwood sites than on the old field sites. The number of reptiles captured per trap day was similar in both habitat types (Table 1).

I caught 12 species of frogs and nine species of salamanders in the hardwood sites as compared to nine species of frogs and seven species of salamanders on the old fields. The difference in total number of frog species in hardwoods versus old fields was not significant (X^2 = 0.018, P > 0.75) nor were the comparable values for salamanders (X^2 = 0.062, P > 0.75). The difference in total number of frog and salamander species combined (Table 1) between hardwoods and old fields was not significant (X^2 = 0.432, P > 0.5).

The total number of frogs captured on the hardwoods was higher than in the old fields, as was the total number of salamanders between these two sites (Table 1). Number of frogs captured per trap day between the two habitat types was significantly different (X^2= 3.2, P > 0.05), but not the number of salamanders (X^2 = 0.77, P > 0.25). The number of frogs and salamanders combined that were caught per trap day was significantly higher in hardwoods than in old fields (Table 1, X^2 = 7.87, P < 0.01). Three times as many juvenile frogs (485) were captured than adults (182) and 3.5 times more adult salamanders (146) were captured than juveniles (42). More adult female frogs were caught than adult males in both habitat types. More female salamanders were captured in the hardwoods, but more males were caught in the old fields.

Four species of frogs dominated the anuran fauna in the hardwood sites, *A. americanus*, *L. clamitans*, *L. palustris*, and *L. sylvaticus*. The number per trap day for all of these species did not differ significantly between HW-N and HW-S (P > 0.5 – 0.75). The number of *A. americanus* (P > 0.5) and *L. clamitans* (P > 0.25) captured per trap day did not differ between hardwood and old field sites. Significantly more *A. opacum* were caught in HW-N (63) than in HW-S (5) (X^2 = 6.97, P < 0.025) but not *E. cirrigera* (P > 0.75). *Ambystoma maculatum*, *D. fuscus*, *H. scutatum*, *P. cinereus*, and *P. ruber* were captured only in HW-N.

I caught all four species of lizards in the old fields but only two of these species in the hardwood sites. Five species of small snakes were caught in the hardwoods compared to three species in the old fields (Table 1). The number of lizards captured per trap day

Table 1. Amphibian and squamate reptile species richness in two replicates of deciduous hardwood (HW N&S) and old field (OF N&S) habitats in Cumberland County, Virginia. Trap days were 2,346 in each HW site and 2,190 in each OF site. Numbers for each sample site are males: females: juveniles.

Species	HW-N	HW-S	Total HW	OF-N	OF-S	Total OF
Amphibians						
Anurans						
Acris crepitans[1]	0:2:1	--	3	--	--	0
Anaxyrus americanus	12:50	3:15:36	116	1:5:21	0:3:5	35
Anaxyrus fowleri	--	0:1:9	10	--	--	0
Hyla chrysoscelis	0:1:0	1:1:0	3	--	--	0
Gastrophryne carolinensis	1:0:0	1:3:0	5	0:1:0	0:1:0	2
Lithobates catesbeianus	0:0:3	0:0:1	4	0:0:3	--	3
Lithobates clamitans	5:12:33	11:11:83	155	1:1:6	0:0:2	10
Lithobates palustris	3:4:88	4:14:36	149	0:0:3	0:0:2	5
Lithobates sylvaticus	0:5:50	9:3:46	113	0:8:0	--	8
Pseudacris crucifer	1:2:0	1:8:2	14	2:3:0	1:1:0	7
Pseudacris feriarum	0:1:1	1:8:2	13	2:3:0	1:1:0	7
Scaphiopus holbrookii	0:0:2	0:1:0	3	--	0:1:0	1
Total number of species	11	11	12	8	7	9
Totals by sex	10:39:228	31:65:215	42:104:443	6:21:33	2:7:9	8:28:42
Total individuals	277	311	588	60	18	78
Number per trap day x 100	11.8	13.2	12.5	2.7	0.8	1.9
Salamanders						
Ambystoma maculatum	0:1:4	--	5	1:0:0	0:0:1	2
Ambystoma opacum	18:29:16	1:4:0	68	1:1:2	--	4
Desmognathus fuscus	4:0:0	--	4	--	--	0
Eurycea cirrigera	13:21:3	4:4:0	45	--	2:0:0	2
Hemidactylium scutatum	1:0:0	--	1	--	--	0
Plethodon cinereus	6:11:4	--	21	6:2:0	--	8
Plethodon cylindraceus	2:0:1	2:1:1	7	1:0:0	--	1
Pseudotriton ruber	7:0:0	--	7	3:0:0	--	3
Notophthalmus viridescens	0:0:3	0:0:4	7	0:0:3	--	3
Total number of species	9	4	9	6	2	7
Total by sex	51:62:31	7:9:5	58:71:36	12:3:5	2:0:1	14:3:6
Total individuals	144	21	165	20	3	23
Number per trap day x100	6.1	1.1	3.5	0.9	0.1	0.7
Total amphibians	421	332	753	80	21	101
Number per trap day x100	17.9	14.2	16.0	3.7	1.0	2.3

Table 1. (continued)

Species	HW-N	HW-S	Total HW	OF-N	OF-S	Total OF
Reptiles						
Lizards						
Plestiodon fasciatus	1:0:1	2:1:1	6	0:2:0	1:0:0	3
Plestiodon inexpectatus	--	--	0	--	0:1:0	1
Sceloporus undulatus	0:1:0	3:0:4	8	5:0:6	3:1:2	17
Scincella lateralis	--	--	0	2:4:0	1:2:1	10
Total by sex	1:1:1	5:1:5	6:2:6	7:6:6	5:4:3	12:10:9
Total individuals	3	11	14	19	12	31
Number per trap day x100	0.1	0.4	0.3	0.9	0.5	0.7
Snakes						
Carphophis amoenus	10:1:0	11:6:0	28	5:3:0	2:0:0	10
Diadophis punctatus	0:0:1	3:0:0	4	--	--	0
Storeria dekayi	1:1:0	2:2:0	6	3:1:0	--	4
Storeria occipitomaculata	0:1:0	--	1	0:4:0	0:0:1	5
Thamnophis sirtalis	--	0:0:1	1	--	--	0
Total number of species	6	5	7	6	6	7
Total by sex	11:3:1	16:8:1	27:11:2	8:8:0	2:0:1	10:8:1
Total individuals	15	25	40	16	3	19
Number per trap day x100	0.6	1.1	0.9	0.7	0.1	0.4
Total reptiles	18	36	54	35	15	50
Number per trap day x100	0.8	1.5	1.2	1.6	0.7	1.1

[1]Subsequent to this study, one of the three cricket frogs (*Acris*) caught was identified as a Southern Cricket Frog (*A. gryllus*) by Micancin et al. (2012) using multivariate morphometric analysis. I do not include this species because the location is well outside its known range (Mitchell & Reay, 1999). Identifying preserved specimens with this technique needs verification before acceptance of the results of Micancin et al. (2012).

in the hardwood sites was not significantly different from the number captured per trap day in the old field sites (X^2 = 1.96, P > 0.1). The number of snakes captured per trap day in these two habitat types was also not significantly different (X^2 = 1.54, P > 0.1). There was no obvious pattern for the frequencies of the sex and age groups for lizards. Male snakes were more numerous than females; only three juveniles were captured. I caught more than twice as many snakes in the hardwoods than in the old field sites; the difference is similar for captures per trap day (Table 1). The number of Eastern Wormsnakes (*Carphophis amoenus*) caught per trap day in both habitat types was not significantly different (X^2 = 0.245, P > 0.5).

DISCUSSION

Daytime visual searches of all habitats available, dipnet sampling of pools and streams, and nighttime road surveys, in addition to the drift fence arrays, provided an assessment of the herpetofauna in this part of the Piedmont. All techniques combined provided occurrence data for 92% of the expected number of amphibian species (93% anurans, 91% salamanders) and 60% of the expected number of squamate reptiles (57% lizards, 61% snakes) based on the range maps in Mitchell & Reay (1999) and Beane et al. (2010). The corresponding number of species documented with the drift fence arrays alone was 84% for amphibians (86% anurans, 82% salamanders) and 36% for reptiles (57% lizards, 28% snakes). This single technique provided a robust estimate of amphibian species richness in the central Virginia Piedmont but an incomplete estimate for squamate reptiles. Most of the frogs are either terrestrial or, if primarily arboreal, occur on the ground occasionally (Dorcas & Gibbons, 2008; Dodd, 2013). Treefrogs were undoubtedly underestimated. All of the salamanders captured are terrestrial or semi-aquatic species that often occur terrestrially during part of their life cycles (Petranka, 1998; Mitchell & Gibbons, 2010). Except for *Scincella lateralis*, the lizards are arboreal but occasionally move among habitat patches or forage on the ground (Gibbons et al., 2009). Snakes are notoriously secretive (Gibbons & Dorcas, 2005) and pitfalls capture only small-bodied species. Thus, the results of my assessment of the amphibian fauna in the two contrasting habitats using a pitfall trapping technique allowed for a reasonable inference about the effect of hardwood removal on this group of vertebrates in the Piedmont.

Frog and salamander species richness in hardwoods and old fields was not significantly different, although more species of both groups were found in the hardwood sites. There were significantly more individual amphibians, however, in hardwood habitats than in the old fields. Clearcutting dramatically alters forest structure by removal of the canopy and exposes the substrate to more sunlight and wind creating a much warmer and drier microclimate (Semlitsch et al., 2009). These changes lead to rapid water loss and high mortality in amphibians (Rothermel & Luhring, 2005; Rittenhouse et al., 2008). Sublethal effects include reduced activity and growth (Todd & Rothermel, 2006). Clearcuts are often avoided by juveniles dispersing from aquatic breeding sites (Patrick et al., 2006). The anurans caught in old fields were likely dispersing individuals because these sites lacked aquatic breeding habitats. Salamanders included few dispersing adults and juveniles (e.g., Spotted Salamander [*Ambystoma maculatum*], Red-spotted Newt [*Notophthalmus viridescens*]). Occurrence of streamside species (e.g., *Desmognathus fuscus*, *Pseudotriton ruber*) in old field sites was due to the presence of a small seepage within 30–40 m of both trap arrays, suggesting that water is more important to amphibians than canopy cover. Except for the small creek, there was no water available for breeding amphibians near HW-S, however, the large number of the ephemeral pool-breeding Marbled Salamander (*Ambystoma opacum*) suggests that at least one of these wetlands was within dispersal distance. Adult and juvenile *A. maculatum* and Wood Frogs (*Lithobates sylvaticus*) dispersed from several road-rut pools about 80 m from HW-N.

Kapfer & Munoz (2012) studied amphibians, reptiles, and small mammals in the North Carolina Piedmont during 2010-2011 using a variety of techniques, including drift fence arrays with a single pitfall trap in the center of the X-shaped array and funnel and box traps alongside the fences. Nine species of frogs and four species of salamanders were captured in the hardwood sites but none in their grassland (= old field) sites. Two lizard species were caught in hardwoods and one in grasslands. Six species of snakes were caught in each of the habitat types. Their results support my conclusion that converting hardwoods to early successional habitat causes significant decline in amphibian populations in the Piedmont.

The drift fence design in this study did not capture many reptiles. The higher number of individuals caught in the old fields was not unexpected due to the heliothermic affinities of most species of the lizards that occur in Virginia. Most of the lizards caught in the hardwoods were in HW-S, the site with the lowest amount of canopy cover. The sample size of one small species of snake allowed for statistical testing. More individuals of *C. amoenus* were captured in the hardwood sites than in the old fields. These snakes are most often captured in forested and wooded habitats

where the relatively moist soil allows burrowing (Mitchell, 1994). The few captures of the other snake species reveal no patterns and statistical testing was not possible.

The effects of clear-cutting hardwood forests and conversion to early successional fields and managed pine plantations on amphibian species richness and diversity are well known (e.g., Keenan & Kimmins, 1993; Grialou et al., 2000; Todd & Andrews, 2008; Semlitsch et al., 2009). All such conversions have contributed to the ongoing decline of amphibian populations in Virginia, the United States, and elsewhere (Mitchell et al., 1999; Stuart et al., 2004; Adams et al., 2013). Hardwood forests in the Virginia Piedmont were reduced dramatically due to agriculture and timber harvest in the 1600s and 1700s. However, forest regrowth in the first half of the 1900s, largely due to abandonment of farmland (Trani et al., 2001), probably allowed expansion of amphibian populations in areas that reached hardwood forest stages through ecological succession.

Despite the fact that large portions of the Virginia Piedmont have remained in agriculture following losses in the 18th century, reclaimed areas such as in private and state forests, state and national parks, and federal military bases have slowed declines in species richness across some of this landscape (e.g., Mitchell & Roble, 1998; Mitchell, 2006, 2007). Intensive harvesting of hardwood forests in the late 1900s and early 2000s for commercial products, however, again converted large areas to early successional stages or these areas were planted with fast growing pine trees (Conner & Hartsell, 2002; Van Lear et al., 2004). Terrestrial amphibian communities in the Piedmont will continue to be fragmented and their habitats reduced to smaller and smaller patches as long as hardwood deforestation continues (Griep & Collins, 2013). Substantial urban growth in the Piedmont may substantially reduce amphibian species richness in this region, leaving only generalist species. As projected for urban areas (McKinney & Lockwood, 1999; McKinney, 2006), future amphibian communities in much of the Virginia Piedmont may be comprised of only habitat generalists consisting of species such as American Bullfrog (*Lithobates catesbeianus*), Green Frog (*L. clamitans*), American Toad (*Anaxyrus americanus*), Fowler's Toad (*A. fowleri*), Cope's Gray Treefrog (*Hyla chrysoscelis*), Gray Treefrog (*H. versicolor*), and Spring Peeper (*Pseudacris crucifer*). Amphibian community homogenization may be the future for much of the central Virginia Piedmont except in protected areas with the remaining mature hardwoods.

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LITERATURE CITED

Adams, M. J., D. A. W. Miller, E. Muths, P. S. Corn, E. H. C. Grant, L. L. Bailey, G. M. Fellers, R. N. Fisher, W. J. Sadinski, H. Waddle, & S. C. Walls. 2013. Trends in amphibian occupancy in the United States. PLoS ONE 8(5): e64347.doi:10.1371/journal.pone. 0064347.

Adler, G. H. 1988. The role of habitat structure in organizing small mammal populations and communities. Pp 288-299 *In* R. C. Szaro, K. E. Severson, & D. R. Pattan (eds.), Management of Amphibians, Reptiles, and Small Mammals in North America. U.S. Department of Agriculture, General Technical Report RM-166, Fort Collins, CO.

Beane, J. C., A. L. Braswell, J. C. Mitchell, W. M. Palmer, & J. H. Harrison, III. 2010. Amphibians and Reptiles of the Carolinas and Virginia. University of North Carolina Press, Chapel Hill, NC. 274 pp.

Bellows, A. S., & J. C. Mitchell. 2000. Small mammal communities in riparian and upland habitats on the upper Coastal Plain of Virginia. Virginia Journal of Science 51: 171-186.

Bellows, S. A., J. C. Mitchell, & J. F. Pagels. 1999. Small mammal assemblages on Fort A.P. Hill, Virginia: habitat associations and patterns of capture success. Banisteria 14: 3-15.

Bellows, S. A., J. F. Pagels, & J. C. Mitchell. 2001. Macrohabitat and microhabitat affinities of small mammals in a fragmented landscape. American Midland Naturalist 142: 345-360.

Brawn, J. D., S. K. Robinson, & F. R. Thompson, III. 2001. The role of disturbance in the ecology and conservation of birds. Annual Review of Ecology and Systematics 32: 251-276.

Buhlmann, K. A., J. C. Mitchell, & C. A. Pague. 1994.

Amphibian and small mammal abundance and diversity in saturated forested wetlands and adjacent uplands of southeastern Virginia. Pp. 1-7 *In* S. D. Eckles, A. Jennings, A. Spingarn, & C. Wienhold (eds.), Proceedings of a Workshop on Saturated Forested Wetlands in the Mid-Atlantic Region: The State of the Science. U.S. Fish and Wildlife Service, Annapolis, MD.

Burruss, C. S., T. S. Fredericksen, & G. Stevens. 2011. Timber harvesting effects on small terrestrial vertebrates and invertebrates on Grassy Hill Natural Area Preserve, Franklin County, Virginia. Banisteria 37: 21-29.

Campbell, H. W., & S. P. Christman. 1982. Field techniques for herpetofaunal community analysis. Pp. 193-200 *In* N. J. Scott, Jr. (ed.), Herpetological Communities. U. S. Fish and Wildlife Service Report 13, Washington, DC.

Conner, R. C., & A. J. Hartsell. 2002. Forest area and conditions. Pp. 357-401 *In* D. N. Wear & J. G. Greis (eds.), Southern Forest Assessment. General Technical Report SRS-53, U.S. Department of Agriculture, Asheville, NC.

Dodd, C. K., Jr. 2013. Frogs of the United States and Canada. 2 vols., Johns Hopkins University Press, Baltimore, MD. 980 pp.

Dorcas, M., & W. Gibbons. 2008. Frogs and Toads of the Southeast. University of Georgia Press, Athens, GA. 237 pp.

Erdle. S. Y. 1997. Demographic features of small mammal assemblages in forest and clearcut habitats in Virginia's central Piedmont. M.S. Thesis, Virginia Commonwealth University, Richmond, VA. 55 pp.

Garriock, C. S., & R. Reynolds. 2005. Results of a herpetofaunal survey of the Radford Army Ammunition Plant in southwestern Virginia. Banisteria 25: 3-22.

Gibbons, W., & M. Dorcas. 2005. Snakes of the Southeast. University of Georgia Press, Athens, GA. 253 pp.

Gibbons, W., J. Greene, & T. Mills. 2009. Lizards and Crocodilians of the Southeast. University of Georgia Press, Athens, GA. 235 pp.

Goldstein M. I., R. N. Wilkins, & T. E. Lachner. 2005. Spatiotemporal responses of reptiles and amphibians to timber harvest treatments. Journal of Wildlife Management 69: 525-539.

Grialou J. A., S. D. West, & R. N. Wilkins. 2000. The effects of forest clearcut harvesting and thinning on terrestrial salamanders. Journal of Wildlife Management 64: 105-113.

Griep, M. T., & B. Collins. 2013. Wildlife and forest communities. Pp. 341-396 *In* D. N. Wear & J. G. Greis (eds.), The Southern Forest Futures Project. General Technical Report SRSD-GTR-178, U.S. Department of Agriculture, Asheville, NC.

Harpole, D. N., & C. A. Haas. 1999. Effects of silvicultural treatments on terrestrial salamanders. Forest Ecology and Management 114: 349-356.

Kapfer, J. M., & D. J. Munoz. 2012. An assessment of herpetofaunal and non-volant mammal communities in sites in the Piedmont of North Carolina. Southeastern Naturalist 11: 65-88.

Keenan, R. J., & J. P. Kimmins. 1993. The ecological effects of clear-cutting. Environmental Review 1: 121-144.

Kirkland, G. L., Jr. 1990. Patterns of initial small mammal community change after clearcutting of temperate North American forests. Oikos 59:313-320.

Knapp, S. M., C. A. Haas, D. N. Harpole, & R. L. Kirkpatrick. 2003. Initial effects of clearcutting and alternative silvicultural practices on terrestrial salamander abundance. Conservation Biology 17: 252-262.

Magurran, A. E. 2004. Measuring Biological Diversity. Blackwell Publishing, Maiden, ME. 256 pp.

McKinney, M. L. 2006. Urbanization as a major cause of biotic homogenization. Biological Conservation 127: 247-260.

McKinney, M. L., & J. L. Lockwood. 1999. Biotic homogenization: a few winners replacing many losers in the next mass extinction. Trends in Ecology and Evolution 14: 450-453.

Micancin, J. P., A. Toth, R. Anderson, & J. T. Mette. 2012. Sympatry and syntopy of the cricket frogs *Acris crepitans* and *Acris gryllus* in southeastern Virginia,

USA and decline of *A. gryllus* at the northern edge of its range. Herpetological Conservation and Biology 7: 276-298.

Mitchell, J. C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, DC. 352 pp.

Mitchell, J. C. 2006. Inventory of Amphibians and Reptiles of Appomattox Court House National Historical Park. Technical Report NPS/NER/NRTR-2006/056. National Park Service, Northeast Region, Philadelphia, PA. Published Report-630329. 52 pp.

Mitchell, J. C. 2007. Inventory of Amphibians and Reptiles of Fredericksburg and Spotsylvania National Military Park. Technical Report NPS/NER/NRTR-2007/072. National Park Service, Northeast Region, Philadelphia, PA. Published Report-660566. 36 pp.

Mitchell, J. C., A. S. Bellows, & C. T. Georgel. 2000. Notes on amphibians and reptiles in riparian and upland habitats on Fort A.P. Hill, Virginia. Banisteria 16: 22-25.

Mitchell, J. C., S. Y. Erdle, & J. F. Pagels. 1993. Evaluation of capture techniques for amphibian, reptile, and small mammal communities in saturated forested wetlands. Wetlands 13: 130-136.

Mitchell, J., & W. Gibbons. 2010. Salamanders of the Southeast. University of Georgia Press, Athens, GA. 324 pp.

Mitchell, J. C., T. K. Pauley, D. I. Withers, P. V. Cupp, A. L. Braswell, B. Miller, S. M. Roble, & C. S. Hobson. 1999. Conservation status of the southern Appalachian herpetofauna. Virginia Journal of Science 50: 13-36.

Mitchell, J. C., & K. K. Reay. 1999. Atlas of Amphibians and Reptiles in Virginia. Special Publication Number 1, Virginia Department of Game and Inland Fisheries, Richmond, VA. 122 pp.

Mitchell, J. C., S. C. Rinehart, J. F. Pagels, K. A. Buhlmann, & C. A. Pague. 1997. Factors influencing amphibian and small mammal assemblages in central Appalachian forests. Forest Ecology and Management 96: 65-76.

Mitchell, J. C., & S. M. Roble. 1998. Annotated checklist of the amphibians and reptiles of Fort A.P. Hill, Virginia. Banisteria 11: 19-32.

Pagels, J. F., S. Y. Erdle, K. L. Uthus, & J. C. Mitchell. 1992. Small mammal diversity in hardwood forest and clearcut habitats in the Virginia Piedmont. Virginia Journal of Science 43: 171-176.

Patrick D. A., M. L. Hunter, Jr., & A. J. K. Calhoun. 2006. Effects of experimental forestry treatments on a Maine amphibian community. Forest Ecology and Management 234: 323–332.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.

Rittenhouse, T. A. G., E. B. Harper, L. R. Rehard, & R. D. Semlitsch. 2008. The role of microhabitats in the desiccation and survival of anurans in recently harvested oak-hickory forest. Copeia 2008: 807-814.

Ross, B., T. Fredericksen, E. Ross, W. Hoffman, M. L. Morrison, J. Beyea, M. B. Lester, B. N. Johnson, & N. J. Fredericksen. 2000. Relative abundance and species richness of herpetofauna in forest stands in Pennsylvania. Forest Science 46: 139-146.

Rothermel B. B., & T. M. Luhring. 2005. Burrow availability and desiccation risk of Mole Salamanders (*Ambystoma talpoideum*) in harvested versus unharvested forest stands. Journal of Herpetology 39: 619-626.

Ryan, T. J., T. Philippi, Y. A. Leiden, M. E. Dorcas, T. B. Wigley, & J. W. Gibbons. 2002. Monitoring herpetofauna in a managed forest landscape: effects of habitat types and census techniques. Forest Ecology and Management 167: 83-90.

Semlitsch, R. D., B. D. Todd, S. M. Blomquist, A. J. K. Calhoun, J. W. Gibbons, J. P. Gibbs, G. J. Graeter, E. B. Harper, D. J. Hocking, M. L. Hunter, Jr., D. A. Patrick, T. A. G. Rittenhouse, & B. B. Rothermel. 2009. Effects of timber harvest on amphibian populations: understanding mechanisms from forest experiments. BioScience 59: 853-862.

Shively, H. S., J. D. Fiore, & T. S. Fredericksen. 2006. Effects of timber harvesting on the abundance and diversity of small mammals on non-industrial private forestlands in south-central Virginia. Banisteria 27: 31-36.

Stuart, S. N., J. S. Chanson, N. A. Cox, B. E. Young, A. S. L. Rodrigues, D. L. Fishman, & R. W. Waller.

2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783-1786.

Todd, B. D., & K. M. Andrews. 2008. Response of a reptile guild to forest harvesting. Conservation Biology 22: 753-761.

Todd, B. D., & B. B. Rothermel. 2006. Assessing quality of clearcut habitats for amphibians: effects on abundances versus vital rates in the Southern Toad (*Bufo terrestris*). Biological Conservation 133: 178-185.

Trani, M. K., R. T. Brooks, T. L. Schmidt, V. A. Rudis, & C. M. Gabbard. 2001. Patterns and trends in early successional forests in the eastern United States. Wildlife Society Bulletin 29: 413-424.

Van Lear, D. H., R. A. Harper, P. R. Kapwluck, & W. D. Carroll. 2004. History of Piedmont forests: implications for current pine management. Pp. 127-131 *In* K. F. Connor (ed.), Proceedings of the 12th Biennial Southern Silvicultural Research Conference. General Technical Report SRS-71. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Vogt, R. C., & R. L. Hine. 1982. Possible placement of pitfall and funnel traps along a drift fence. Pp. 201-217 *In* N. J. Scott (ed.), Herpetological Communities. U.S. Fish and Wildlife Service, Wildlife Research Report 13, Washington, DC.

Zar, J. H. 2009. Biostatistical Analysis. 6th Edition, Prentice Hall, Upper Saddle River, NJ. 960 pp. + appendices.

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Caddisfly Species New to, or Rarely Recorded from, the State of Virginia (Insecta: Trichoptera)

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ABSTRACT

Eight species of caddisflies (Trichoptera) are added to the 361 species recorded by 2009 from the state of Virginia. There are now 369 species confirmed from the state. The new records are: *Agapetus baueri* and *A. kirchneri* (Glossosomatidae), *Hydroptila ampoda*, *H. nicoli*, *Neotrichia collata*, *Oxyethira abacatia* (Hydroptilidae), *Oligostomis ocelligera* (Phryganeidae), and *Polycentropus colei* (Polycentropodidae). Significant range extensions are recorded for three species rarely reported from the state: *Adicrophleps hitchcocki* (Brachycentridae), *Hydroptila lonchera* (Hydroptilidae), and *Lepidostoma serratum* Lepidostomatidae). Two additional species are tentatively recorded based on females that need associated males for confirmation: *Oxyethira dunbartonensis* (Hydroptilidae, this would be another new state record if confirmed), and *Theliopsyche grisea* (Lepidostomatidae, a range extension). *Agapetus rossi* has been shown to be a synonym of *A. walkeri* (Glossosomatidae).

Key words: caddisfly, Brachycentridae, Glossosomatidae, Hydroptilidae, Lepidostomatidae, Phryganeidae, Polycentropodidae, new state records, range extensions, Virginia.

INTRODUCTION

In 2009 we (Flint et al., 2009) completed our inventory of caddisfly species known from Virginia. At that time we had recorded 361 species in the state. In this paper are recorded eight more species recently discovered in Virginia, bringing the state's total to 369. Of these eight new state records, two are the result of a revision of the genus *Agapetus* wherein two of the new species are recorded in the state (Etnier et al., 2010), the remaining six are the result of insect trapping with Malaise traps in the Bull Run Mountains Conservancy (=BRMC) in the years 2011, 2012 and 2013. In addition to these new state records, three species are recorded with significant range expansions, two are tentatively recorded on the basis of females only that need males for confirmation of identification (one of which would be a new state record if confirmed), and one is a recent name change.

MATERIALS AND METHODS

Since the completion of our survey of VA caddisflies in 2009, I am aware of only one paper published that adds species to the state list. Etnier et al. (2010) revised the genus *Agapetus* from eastern and central USA. They discovered 12 previously unknown species, primarily by utilizing a different collecting technique that entailed collecting larvae and pupae in their pupal cases primarily from springs and their runs in early spring (April and May) and then rearing them to adulthood. This is a surprisingly successful technique for uncovering previously unknown species, at least in this genus. This technique resulted in all of the VA records for *A. kirchneri.*

All other records were obtained during a survey (2011-2013) of certain insect groups in the BRMC initiated by Dr. David R. Smith of the USDA with help from Dr. Thomas J. Henry (USDA) and myself (SI). We are most grateful to Michael J. Kieffer, Executive Director of the BRMC, for enthusiastic permission and help with this project. Our traps have been placed in two primary areas, one near the Conservancy headquarters (38°49.5'N, 77°42.3'W) (3 or 4 single traps per year placed at various sites called mountain house, Beverly Mill or Broad Run, swamp, fern valley, chestnut ridge, cemetery and cemetery gulch) with a nearby associated grouping of three traps along the east

end trail (38°49.6'N, 77°41.9'W), the second grouping of three or four traps to the north of the headquarters in Jackson Hollow scattered around a former campground (38°52.7'N, 77°41.9'W). In 2013, we went outside the BRMC and set two traps on the western slopes of the mountains: the first adjacent to the property of Dr. Shurberg at 4566 Hopewell Road, in Fauquier Co. (38°52.1'N, 77°42.21'W), the second at a spring run in the Roland Farm woods off Bust Head Road (38°50.6'N, 77°49.6'W; this trap was taken down by Black Bears early in the season). Many of the traps were placed close to a first or second order stream, but the Bull Run near Beverly Mill is probably a third order stream. A few of our traps were vandalized by humans in 2012 and 2013 (two each year), but bears were a bigger problem: they destroyed seven of nine in 2012, but only two of 11 in 2013.

An asterisk (*) before the specific name in the section that follows indicates a species herein recorded from Virginia for the first time. Unless indicated otherwise, the material is deposited in the collection of the National Museum of Natural History, Smithsonian Institution (NMNH). The other depositories are: CASC = California Academy of Sciences, CUAC = Clemson University, INHS = Illinois Natural History Survey, ROME = Royal Ontario Museum, UMSP = University of Minnesota, UT = University of Tennessee, and VMNH = Virginia Museum of Natural History.

Family Brachycentridae

Genus *Adicrophleps*

Adicrophleps hitchcocki Flint. This species had been known from six counties along the Blue Ridge from Bedford to Rappahannock (Flint et al., 2008). In the three years of collecting in the BRMC, only one specimen was taken, well to the east of its previously known distribution.

Prince William Co., BRMC, Jackson Hollow, far Malaise trap, 38°52.6'N, 77°41.4'W, 16 Apr-2 May 2013, 1♂.

Family Glossosomatidae

Genus *Agapetus*

In 2010, Etnier, Parker, Baxter, and Long published "A review of the genus *Agapetus* in eastern and central North America, with description of 12 new species". In this work, two of the new species were recorded from VA, and one other species known from the state had its name changed. These data are presented below.

**Agapetus baueri* Etnier, Parker & Baxter. This newly described species was recorded from two collections made in Floyd Co., VA in addition to numerous collections from NC and TN.

Floyd Co., Blue Ridge Parkway, outflow of Mabry Mill pond, downstream to approximately 30 m, Milepost 176.2 right, 8 June 2006, 2 ♂ (UT). Blue Ridge Parkway confluence of 2 streams feeding Mabry Mill pond, along paved trail, Milepost 176.2 left, 20 July 2007, 1 ♂ (UT).

**Agapetus kirchneri* Parker, Etnier & Baxter. The holotype, allotype, and many paratypes of this new species were from Lee Co., VA, with additional records from Smyth and Washington Cos., as well as KY and TN. Lee Co., Cumberland Gap National Historical Park, Station Creek at horse barn, 36.6040°N, 83.6285°W, 5 April 2007, emerged 25 April-7 May, J. L. Robinson, holotype ♂ (NMNH), allotype ♀ (NMNH), paratypes 8♂, 4♀ (CASC, CUAC, INHS, ROME, UMSP, NMNH, UT). Lee Co., northern trib. to Hardy Cr. along US58, 5.2 rd mi ne of Rose Hill, 20 April 2000, 13 larvae/ prepupae, 8♂, 7♀ mature pupae/adults (UT). Smyth Co., Laurel Spring Rd., 0.6 rd mi s of I-81 mile 43 overpass, 27 April 2003, 5 larvae, 2 pupae, 3♀ mature pupae (UT). Washington Co., Rockhouse Run at jct. VA 710 & VA 711, near Alvarado, 4 May 2003, 6 larvae/prepupae, 2 pupae, 17♂, 12♀ mature pupae/adults (UT).

Agapetus walkeri Betten & Mosely. This species was previously known as *A. rossi* Denning and reported as such by Flint et al. (2004). The synonymy was established in the aforementioned paper by Etnier et al. (2010).

Family Hydroptilidae

Genus *Hydroptila*

**Hydroptila ampoda* Ross. Although described from NS and QC in 1944, it has been recorded a number of times over the years from eastern Canada, New England, PA, and southwest of VA in KY and TN, with a western record from MN. These records from northern VA, therefore, help fill in the gap in known distribution in eastern USA. It is one of four species of the *tineoides* group found in the BRMC, the others being: *H. fiskei* Blickle, *H. hamata* Morton, and an apparently undescribed species. Although females of the group are commonly taken, it is not yet possible to distinguish, nor associate, them with any one species.

Prince William Co., BRMC, Jackson Hollow, Malaise trap #1, 38°52.6'N, 77°41.4'W, 22 July-

9 August 2011, 1♂ (NMNH); same, but Malaise traps #2, #3, #4, 21 April-20 September 2012, 6 collections, 15♂; same, but all 3 traps, 3 May-5 August 2013, 5 collections, 5♂. Fauquier Co., Shurberg home, 4566 Hopewell Rd., 38.8678°N, 77.7035°W, 3-22 May 2013, 1♂.

Hydroptila lonchera Blickle & Morse. This species was previously known in VA only from one specimen taken in Louisa Co. on 25 August 1977 (Flint et al., 2004). It was fairly commonly taken in the Malaise traps located in Jackson Hollow in all three years, but, oddly, no females obviously belonging to this species were seen.

Prince William Co., BRMC, Jackson Hollow, stream above dam, 27/28 May 2010, A.V. Evans, 1 ♂ (NMNH). Prince William Co., BRMC, Jackson Hollow, stream, field & far Malaise traps, 38°52.6'N, 77°41.4'W, 28 April-31 August 2011, 10 collections, 18♂ (NMNH, VMNH); same, but 21 April-20 September 2012, 12 collections, 34♂; same, but 23 May-5 August 2013, 3 collections, 4 ♂.

**Hydroptila nicoli* Ross. This species was described in 1941 from a few specimens taken in Nova Scotia, and was not recorded again until early in 2011 when three specimens were collected in Clinton Co. in upstate New York (Myers et al., 2011), about 450 miles (ca. 725 km) NNE of the BRMC. It is common in Jackson Hollow and has been taken in every Malaise trap operated there.

Prince William Co., BRMC, Jackson Hollow, stream, field & far Malaise traps, 38°52.6'N, 77°41.4'W, 13 May-31 August 2011, 16 collections, 47♂, 28♀ (NMNH, VMNH); same, but 21 April-20 September 2012, 12 collections, 52♂, 110♀; same, but 23 May -23 September 2013, 12 collections, 23♂, 27♀.

Genus *Neotrichia*

**Neotrichia collata* Auths. (= *doppelganger* Keth MS). Andrew Keth in his doctoral dissertation (Keth, 2002) discovered that the species long considered (Ross 1944, etc.) to be *N. collata* was different from the type of *collata*. He proposed the MS name of *doppelganger* for the incorrect concept; unfortunately the description has not been published, but I understand that the paper is in preparation. It has been recorded from AL north to ME and west to IL with an outlier from UT, but not previously from VA. We took it at Jackson Hollow, Beverly Mill, and Schurberg home in most Malaise traps in all years.

Prince William Co., BRMC, Jackson Hollow, Malaise traps, 38°52.6'N, 77°41.4'W, 25 June-21 July 2011, 3 collections, 1♂, 2♀ (NMNH); same, but 28 June-13 July 2012, 2 collections, 2♂, 1♀; same, but 26 June-16 July 2013, 2 collections, 4♂; same, but Broad Run at Beverly Mill, 38°49.5'N, 77°42.6'W, 21 September-18 October 2012, 1♂. Fauquier Co., Shurberg home, 4566 Hopewell Rd., 38.8678°N, 77.7035°W, 26 June-28 August 2013, 3 collections, 26♂, 42♀ (NMNH).

Genus *Oxyethira*

**Oxyethira abacatia* Denning. This species has previously been reported from TX to FL and north to Macon Co., NC. These VA records are approximately 430 miles (almost 700 km) NE of the NC record. It was not collected in 2011 and rather uncommonly taken in 2013, but was taken in all traps in Jackson Hollow in 2012.

Prince William Co., BRMC, Jackson Hollow, Malaise traps, 38°52.6'N, 77°41.4'W, 26 May-20 September 2012, 9 collections, 20♂, 6♀ (NMNH); same, but 26 June-16 July 2013, 1♀. Fauquier Co., Shurberg home, 4566 Hopewell Rd., 38.8678°N, 77.7035°W, 3 May-5 August 2013, 3 collections, 1♂, 4♀ (NMNH).

Oxyethira species, probably *dunbartonensis* Kelley. This is another rarely reported species known from the southeastern United States. It is known for certain only from GA and SC, the closest locality being in Aiken Co., SC about 450 miles (ca. 725 km) to the south. Unfortunately, it is known in the BRMC only from one female collected in 2012. A male is needed to fully verify the identification although the identity of the female seems pretty secure. If the identity is confirmed, it would be a new species to the state of VA.

Prince William Co., BRMC, Jackson Hollow, Malaise trap #2, 38°52.6'N, 77°41.4'W, 14 July-3 August 2012, 1♀ (NMNH).

Family Lepidostomatidae

Genus *Lepidostoma*

Lepidostoma serratum Flint & Wiggins. There were two records published (Flint et al., 2008) of this species in Virginia, both from the eastern margin of the Blue Ridge in southwestern VA about 275 miles SW. It is known from CT to LA. This record from Prince William Co. thus expands its known range in the state from the SW corner to the northern Piedmont.

Prince William Co., BRMC, Jackson Hollow, field Malaise trap, 38°52.8'N, 77°41.4'W, 24 Sept-4 Nov 2013, 2♀ (NMNH).

Genus *Theliopsyche*

Theliopsyche species, probably *grisea* (Hagen). We recorded three collections of single males of this species in our study (Flint et al., 2008), all from the Blue Ridge and Alleghenian mountains. I have been unable to find a verified female of this species, the few females described in other species of the genus are clearly different from the one recorded below. The most logical and virtually only choice left in the genus is *T. grisea*, but until either a male is taken or a confirmed female that can be compared is found, I feel it best to leave its identity questioned. A record from the eastern lowlands will mark a considerable expansion of its distribution in VA.

Prince William Co., BRMC, Jackson Hollow, Malaise trap #1, 38°52.6'N, 77°41.4'W, 11-24 June 2011, 1♀ (NMNH).

Family Phryganeidae

Genus *Oligostomis*

**Oligostomis ocelligera* (Walker). Of the two species of *Oligostomis* known from eastern North America, *O. pardalis* was recorded from a few specimens taken in Giles Co. and *O. ocelligera* mentioned as possibly to be found in the western part of the state (Flint et al., 2008). Specimens have now been taken in VA, but not in the west! It is a species limited to northeastern North America from near the James Bay in Quebec south to TN and along the coastal provinces and states from Newfoundland south to NJ and west to WI, IN, and TN. It has not been recorded from south of PA among the mid-Atlantic states. This record is about 150 miles (ca. 240 km) southeast of the closest record in Fayette Co., PA. It was only taken in 2013 from the two traps closest to Broad Run near Beverly Mill.

Prince William Co., Broad Run at Beverly Mill, 38°49.5'N, 77°42.6'W, 16 Apr-2 May 2013, 1♂ (NMNH). Prince William Co., Mountain House, 38°49.5'N, 77°42.3'W, 3-22 May 2013, 1♀ (NMNH).

Family Polycentropodidae

Genus *Polycentropus*

**Polycentropus colei* Ross. This rather infrequently collected species was described from Great Smoky Mountains National Park in TN, and since recorded from PA, WV, and QC. The female has not been described. The two females I here associate with this species have had their abdomens cleared and their genitalia are identical and resemble those of the closely related *P. rickeri* Yamamoto, but offer some clear, but minor distinctions. Everything considered, it seems most likely that these examples are females of *P. colei*. All examples were taken in 2013, two from Jackson Hollow, the third from just north of the Beverly Mill.

Prince William Co., BRMC, Jackson Hollow, stream Malaise trap, 38°52.7'N, 77°41.3'W, 23 May-6 June 2013, 1♂; same, but far malaise trap, 38°52.6'N, 77°41.4'W, 7-25 June 2013, 1♀ (NMNH). Prince William Co., cemetery gulch, 38.827°N, 77.709°W, 7-25 June 2013, 1♀ (NMNH).

LITERATURE CITED

Etnier, D. A., C. R. Parker, J. T. Baxter, Jr., & T. M. Long. 2010. A review of the genus *Agapetus* Curtis (Trichoptera: Glossosomatidae) in eastern and central North America, with description of 12 new species. Insecta Mundi 0149: 1-77.

Flint, O. S., Jr., R. L. Hoffman, & C. R. Parker. 2004. An annotated list of the caddisflies (Trichoptera) of Virginia: Part I. Introduction and families of Annulipalpia and Spicipalpia. Banisteria 24: 23-46.

Flint, O. S., Jr., R. L. Hoffman, & C. R. Parker. 2008. An annotated list of the caddisflies (Trichoptera) of Virginia: Part II. Families of Integripalpia. Banisteria 31: 3-23.

Flint, O. S., Jr., R. L. Hoffman, & C. R. Parker. 2009. An annotated list of the caddisflies (Trichoptera) of Virginia: Part III. Emendations and biogeography. Banisteria 34: 3-16.

Keth, A. C. 2002. Taxonomy of the genus *Neotrichia* and related taxa (Trichoptera: Hydroptilidae: Neotrichiini). Unpublished Ph.D. thesis, Pennsylvania State University, State College, PA. 327 pp.

Myers, L. W., B. C. Kondratieff, T. B. Mihuc, & D. E. Ruiter. 2011. The mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) of the Adirondack Park (New York State). Transactions of the American Entomological Society 137: 63-140.

Ross, H. H. 1944. The caddis flies, or Trichoptera, of Illinois. Bulletin of the Illinois Natural History Survey 23: 1-326.

Shorter Contributions

Banisteria, Number 43, pages 93-94

THE *OPUNTIA* CACTUS BUG *CHELINIDEA VITTIGER* REDISCOVERED IN VIRGINIA (HETEROPTERA: COREIDAE). — The *Opuntia* Cactus Bug (*Chelinidea vittiger* Uhler) feeds on the Eastern Prickly-pear Cactus (*Opuntia humifusa* (Raf.) Raf.), and ranges from Virginia to Florida, west to Nebraska and the Southwest, and north to southwestern Canada (Herring, 1980). The species is easily recognized by the yellow stripes on the head, the three-sided antennal articles, and its occurrence on prickly pear cacti (Hoffman, 1991). Eastern Prickly-pear Cactus occurs sporadically throughout the Commonwealth of Virginia, mostly in dry sandy or rocky, open habitats from coastal dunes to the Appalachian Mountains. Only one species of *Opuntia* is thought to occur in Virginia (Weakley et al., 2012).

Hoffman (1975) stated that "the occurrence of *C. vittiger* in Virginia stands upon very inadequate documentation," presumably based on two factors. First, is the potential for one of the two Virginia records (specimen cited by Uhler, 1863) to have been taken from the Kanawha River valley in what is now West Virginia, prior to its political separation from Virginia. Second, a nymph taken from Herndon, Virginia in 1911, has never been substantiated via surveys in that area, and may have been mislabeled or misidentified (Hoffman, 1994). Due to the rapid development of suburban areas around Washington, DC (including Herndon) during the last 50 years, the coreid seems less likely to occur there. These factors, and a host of negative surveys by himself and others, led Hoffman (1994) to propose that the species "be removed from the list of Virginia coreids."

Over the last 15 years, I have searched unsuccessfully at numerous sites containing *Opuntia* cacti in hopes of finding *C. vittiger*. However, my first nocturnal foray for this species (albeit unintentional) yielded a positive result. On 24 August 2010 while trapping bats at a Scott County cave, a lull in the bat trapping led me to make a brief search of the abundant prickly pear cacti in the surrounding pasture. Eventually, I noticed a slight movement on one of the cactus pads, and then another. With the aid of my head lamp, I collected five adults of a dull yellow and black hemipteran (Fig. 1) from a single cluster of *Opuntia*. I never saw them elsewhere in the pasture despite looking at hundreds of cacti. These specimens were examined further, checked against online resources and field guides, and were later confirmed by Dr. Hoffman to be *C. vittiger*. Finally, this true bug had been restored to the fauna of the Commonwealth!

Fig. 1. Two adults of the *Opuntia* Cactus Bug (*Chelinidea vittiger*) collected on 24 August 2010 from a site in Scott County, Virginia (photo by C. S. Hobson).

It remains to be determined if this species is more nocturnal than diurnal. It might be worthwhile to revisit other sites with *Opuntia* at night to determine if *C. vittiger* can be found more easily with flashlight in hand. Additional surveys are needed to determine the extent and condition of the Scott County population.

The collection site is approximately 2 km (1.2 miles) east of Nickelsville, Scott County, Virginia, and consists of a dry rocky pasture with abundant fescue, thistle, and *Opuntia*. The site has several cave openings and numerous sinkholes. Copper Creek flows along the northern boundary of the site. Voucher specimens are deposited in the Virginia Museum of Natural History, Martinsville, Virginia.

ACKNOWLEDGEMENTS

I am particularly grateful to the late Dr. Richard L. Hoffman (Virginia Museum of Natural History, Martinsville) for his comments on this manuscript, and his examination of the specimens. Richard encouraged me (and others) over the years to search for this species, and his advice and enthusiasm in the pursuit of this bug were crucial to its discovery. He will be greatly missed. Special thanks to Thomas J. Henry with the USDA ARS Systematic Entomology Laboratory at the Smithsonian Institution for his suggestions and comments on the manuscript.

LITERATURE CITED

Herring, J. L. 1980. A review of the cactus bugs of the genus *Chelinidea* with the description of a new species (Hemiptera: Coreidae). Proceedings of the Entomological Society of Washington 82: 237-250.

Hoffman, R. L. 1975. The Insects of Virginia: No. 9. Squash, broad-headed, and scentless plant bugs of Virginia. (Hemiptera: Coreoidea: Coreidae, Alydidae, Rhopalidae). Bulletin of the Research Division, Virginia Polytechinc Institute and State University 105: 1-52.

Hoffman, R. L. 1991. *Opuntia* squash bug. Pp. 226-228 *In* K. Terwilliger (coord.), Virginia's Endangered Species. McDonald and Woodward Publishing Company, Blacksburg, VA. 672 pp.

Hoffman, R. L. 1994. Additions and emendations to the Virginia fauna of "true bugs" (Heteroptera: Cydnidae, Scutelleridae, Pentatomidae, Alydidae). Banisteria 3: 15-19.

Uhler, P. R. 1863. Hemipterological Contributions, No. 2. Proceedings of the Entomological Society of Philadelphia 2: 361-366.

Weakley, A. S., J. C. Ludwig, & J. F. Townsend. 2012. Flora of Virginia. B. Crowder (ed.). Foundation of the Flora of Virginia Project Inc., Richmond. Botanical Research Institute of Texas Press, Fort Worth, TX. 1,554 pp.

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TWO ROBBER FLIES (DIPTERA: ASILIDAE) NEW TO THE VIRGINIA FAUNA, PLUS NOTES ON ADDITIONAL POORLY KNOWN SPECIES.—In 2010, I published a list of the robber flies of Virginia that included 115 confirmed species plus an additional eleven considered possible for a total of 126 (Bedell, 2010). Since that time, two species, *Orthogonis stygia* and *Leptogaster murina*, have been recorded in Virginia raising the confirmed species to 117 for a total of 128 (neither was on my hypothetical species list). This note also updates data on six additional species that were previously documented by few records, and presents occurrence evidence that *Nicocles pictus* overwinters in the adult stage. I have maintained the same format as the 2010 paper, with species presented in alphabetical order according to subfamily, and with counties italicized.

Asilinae

Neomochtherus auricomus (Hine)

On 5 September 2013, I observed this species to be fairly common (about 20 adults observed in a 2-hour period) in the understory of second growth deciduous woods at Pocahontas State Park, *Chesterfield Co.* Perch sites included leaves of American Holly *(Ilex opaca*). Specimens and photographs (BugGuide photos #837779-80) were obtained. This species may be underreported due to its appearance late in the season.

Proctacanthus heros (Wiedemann)

This impressive species, the largest of our asilids, was included on the Virginia list based on a specimen taken in 1938. I collected a male on 18 August 2011 and observed several more at Cherry Orchard Bog Natural Area Preserve (NAP) in *Sussex Co.* Later that same day I photographed one at Chub Sandhill NAP (BugGuide photo #593537), also in *Sussex Co.* A. V. Evans collected a female at Blackwater Ecological Preserve in *Isle of Wight Co.* in a Malaise trap run from 23 September to 5 October 2010. This specimen is in my collection.

Brachyrhopalinae

Ceraturgus aurulentus (Fabricius)

I took a female specimen of this apparently very rare species in Pocahontas State Park (*Chesterfield Co.*) on 5 September 2013. Habitat was second growth dry deciduous woods with low understory. In appearance and behavior, it was a very convincing mimic of a yellow jacket wasp (*Vespula* sp.). Even its flight was very unlike any asilid I know, being low to the ground and in curved patterns.

After capturing the initial specimen, I returned to the site three times before observing another and taking photographs of an ovipositing female and habitat on 11 September (BugGuide # 840074-76, 840080). My last observation (one adult) was on 2 October.

Ceraturgus aurulentus is apparently very rare, as "Fewer than two dozen specimens have been collected in the past 200 years" (Barnes, 2008). However, this species was recently also photographed in North Carolina and Wisconsin in late August and September (BugGuide.net, 2013). Perhaps its apparent rarity is at least partially a result of its remarkable mimicry and late season phenology.

Cyrtopogon lutatius (Walker)

I found this small robber fly to be localized on piles of downed deciduous logs at Pocahontas State Park, *Chesterfield Co.* I recorded as many as 20 adults at one site, with my earliest date being 2 May. All of my observations have been in May. Several June visits to piles of logs where they occurred earlier resulted in no sightings. I obtained two specimens, and photographed a male (BugGuide #511537).

Nicocles pictus (Loew)

The phenology of this asilid is unlike any other in Virginia. It is present throughout very early spring into May, disappearing in the summer, then reappearing in late fall. Since my 2010 paper, I have observed this species on warm days throughout the winter months, but I lack records for December. I have observed adults at Pocahontas State Park on 17 February 2011; 7 January (see photo and discussion at BugGuide #605947), 1 February, and 1 March 2012; and 9 January, 16 February, and 21 November 2013. Especially the January dates indicate that *N. pictus* overwinters in the adult stage.

Dasypogoninae

Diogmites salutans Bromley

I had included this southeastern species based on a female record from Smithfield cited by S. Bromley in his original description (Bromley, 1936). I have since found *D. salutans* to be numerous in the power line cut at Cherry Orchard Bog NAP in *Sussex Co.* My observation dates range from 22 July to 21 August. I have ten specimens in my collection.

Laphriinae

Laphria sacrator Walker

This northern species was previously documented in Virginia by one record from *Rockingham Co.* I collected two specimens in *Highland Co.* from the Bearcamp Knob area at an elevation of about 3500 feet (1067 m) on 29 June 2011.

Orthogonis stygia (Bromley) **New state record!**

On 18 August 2011, I accompanied Arthur Evans and Anne Wright on a field trip to Sussex County, including Cherry Orchard Bog NAP. The following day Dr. Evans sent me photographs of an unknown asilid he had observed at this site, which I suspected might be the very rare *O. stygia.* I forwarded the photographs (Figs. 1-2) to Dr. Eric Fisher, who immediately confirmed the identification based on the unique features of this robber fly, including shape of the proboscis, antennae, and wing venation, all visible in the photographs (E. Fisher, pers. comm.).

Numerous subsequent trips to this location to relocate *O. stygia* have been unsuccessful. I returned twice during the week following the initial discovery in 2011, then four times in 2012 (31 May, 8 and 27 June, and 22 July).

This species has been regarded as very rare since its original description from a lone female specimen from

Figs. 1-2. *Orthogonis stygia* with ichneumonid wasp prey at Cherry Orchard Bog Natural Area Preserve, Sussex Co., Virginia. Photos by Arthur V. Evans.

North Carolina (Bromley, 1931), where it has not been recorded since. However, it has been observed recently in Texas (Taber & Fleenor, 2003) and Arkansas (Barnes, 2007). All other sightings have been in June and July, so the Virginia record represents a late date. The prey item in the photographs can be identified as an ichneumonid wasp (R. Kula, pers. comm.). The habitat where *Orthogonis* was observed at Cherry Orchard Bog NAP can be generally described as a closed-canopy mesic woods, somewhat similar to the habitat described in Arkansas (Barnes et al., 2007), but the topography here is essentially flat.

Leptogastrinae

Leptogaster murina Loew **New state record!**

This is considered a Midwestern species, but there is one other record for the eastern United States from Maryland (Scarbrough, 1974). I have collected *L. murina* at three sites in Virginia, including native grasslands at the Radford Army Ammunition Plant in *Montgomery Co.* (3 June 2010), an old field in *Alleghany* Co. (31 May 2010), and a site in *Goochland Co.* (16 May 2013). Three specimens from the latter site were donated to the NMNH.

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LITERATURE CITED

Barnes, J. K. 2008. Review of the genus *Ceraturgus* Wiedemann (Diptera: Asilidae) in North America north of Mexico. Zootaxa 1766: 1-45.

Barnes, J. K., N. Lavers, & H. Raney. 2007. Robber flies (Diptera: Asilidae) of Arkansas, U.S.A.: Notes and a checklist. Entomological News 118: 241-258.

Bedell, P. 2010. A preliminary list of the robber flies (Diptera: Asilidae) of Virginia. Banisteria 36: 3-19.

Bromley, S. W. 1931. New Asilidae, with a revised key to the genus *Stenopogon* Loew: (Diptera). Annals of the Entomological Society of America 24: 427-435.

Bromley, S. W. 1936. The genus *Diogmites* in the United States with descriptions of new species (Diptera: Asilidae). Journal of the New York Entomological Society 44: 225-237.

BugGuide.net. http://bugguide.net/node/view/15740 Accessed 1 November 2013.

Scarbrough, A. G. 1974. A faunistic study of Asilidae (Diptera) at three locations in northern Baltimore County, Maryland: incidence, relative abundance and seasonal distribution. Proceedings of the Entomological Society of Washington 76: 385-396.

Taber, S. W., & S. B. Fleenor. 2003. Range extension, habitat, and review of the rare robber fly *Orthogonis stygia* (Bromley). Southwestern Entomologist 29: 85-87.

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Banisteria, Number 43, pages 96-98

HARRIS' CHECKERSPOT (*CHLOSYNE HARRISII*), A NORTHERN BUTTERFLY NEW TO THE FAUNA OF VIRGINIA (LEPIDOPTERA: NYMPHALIDAE). — Harris' Checkerspot (*Chlosyne harrisii*) is a distinctively patterned black and orange butterfly that ranges across Canada from Nova Scotia and Prince Edward Island west to Manitoba and south in the United States to Ohio and northern Pennsylvania, with disjunct populations in northeastern West Virginia (Opler, 1992; Allen, 1997; Cech & Tudor, 2005). The species has one adult generation per year in early summer and the communal larvae build silken nests on the sole known hostplant, flat-topped white aster (*Doellingeria umbellata*, formerly *Aster umbellatus*). Reported habitats of *C. harrisii* include wet pastures, marshes, bogs, and damp meadows (Opler, 1992; Allen, 1997; Cech & Tudor, 2005). Allen (1997) noted that adults can be found nectaring in open or brushy upland areas and are often found along road banks.

Although the closely related and similar Silvery Checkerspot (*Chlosyne nycteis*) is rather common and widespread in Virginia (Clark & Clark, 1951; Pavulaan, 1997; personal observations of authors), especially in the mountains and portions of the Piedmont, Harris' Checkerspot has not been reported previously from Virginia. Allen (1997) recorded *C. harrisii* from four montane counties in northeastern West Virginia, two of which (Pendleton and Pocahontas) border on Virginia. Thus, despite the lack of documented records, it seemed possible that this species might occur in the mountains

Fig. 1. Dorsal view of adult *Chlosyne harrisii* from Highland County, Virginia (photo by Allen Bryan).

of western Virginia in areas where the hostplant is present. Allen (1997) noted that *C. harrisii* is common near Spruce Knob Lake in Randolph Co., West Virginia, but it has not been found by SMR about 15-20 km (9-12 mi) farther south in the Laurel Fork Recreation Area of the George Washington National Forest in extreme northwestern Highland Co., Virginia despite numerous visits spanning the past two decades.

On 10 June 2007, one of us (AB) observed and photographed (Fig. 1) several adult Harris' Checkerspots in a beaver meadow along Straight Fork in northwestern Highland County, apparently the first documented record of this species in Virginia. We visited the site together two weeks later (23 June 2007), but did not find *C. harrisii* on that date, perhaps indicating that the flight season was over or nearly so. A few adults of *C. harrisii* have been found in this same area in subsequent years by us (mostly AB) and several other observers on the following dates: 6 June 2008, 11, 13, and 27 June 2009, 2 and 5 June 2010, 17 and 23 June 2011, and 15 June 2013. Unpublished reports of butterflies observed or collected in this same wetland between the mid-1970s and late 1990s, including visits on 12 and 22 June 1974, 17 July 1982, 22 June 1989, 21 June 1995, and 23 June 1998, do not include *C. harrisii*. Perhaps most of these surveys occurred near the end or after the relatively short flight season of this species.

On 7 June 2010, SMR and Irvine Wilson discovered a second Virginia population of *C. harrisii* in wet meadows along Back Creek west of Hightown, also in northwestern Highland County. A total of 10 adults was observed on that date. A return visit to this site by SMR three weeks later (29 June 2010) did not yield any observations of *C. harrisii*, but several adults were found during the period of 6-10 June 2011. One adult was observed nectaring on Pennsylvania Blackberry (*Rubus pensilvanicus*) (Fig. 2). This is the southernmost known site for *C. harrisii* in Virginia and perhaps its entire range.

On 15 June 2011, SMR discovered a third Virginia population of *C. harrisii* along an unnamed headwater tributary of Laurel Fork within several hundred meters of the West Virginia state line. This is apparently the largest of the three known Virginia populations of *C. harrisii*; more than 20 adults were seen on this date and at least 25 were observed the following day. Adults were nectaring on white clover (*Trifolium repens*) flowers in the lawn of a pond-side cabin, occasionally chasing off conspecifics to gain access to flowers.

Harris' Checkerspot is a peripheral species in Virginia, barely occurring within the state's borders and occupying a very limited portion of northwestern Highland County. All three known locations are within 5 km (3 mi) of the West Virginia state line, and within 10 km (6 mi) of one another. Elevations of these sites range from approximately 884 to 1128 meters (2900-3700 feet) above sea level. Other northern, state-rare butterflies that occur syntopically with *C. harrisii* at one or more sites in Virginia include Pink-edged Sulphur (*Colias interior*), Atlantis Fritillary (*Speyeria*

Fig. 2. Ventral view of adult *Chlosyne harrisii* nectaring on Pennsylvania Blackberry (*Rubus pensilvanicus*) in Highland County, Virginia (photo by Steven Roble).

atlantis), Silver-bordered Fritillary (*Boloria selene*), Two-spotted Skipper (*Euphyes bimacula*), and Long Dash (*Polites mystic*). The diurnal arctiid moth *Ctenucha virginica*, another northern species, was collected at one site and Baltimore Checkerspot (*Euphydryas phaeton*), a declining butterfly in the region, was recorded at two of the *C. harrisii* sites.

The Virginia population is assignable to the subspecies *Chlosyne harrisii liggetti* (Avinoff), which is known to inhabit the northeastern United States. It is larger and dorsally darker than the more northerly distributed nominate subspecies. A voucher specimen from the Back Creek site will be deposited in the Virginia Museum of Natural History, Martinsville, VA.

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LITERATURE CITED

Allen, T. J. 1997. The Butterflies of West Virginia and Their Caterpillars. University of Pittsburgh Press, Pittsburgh, PA. 388 pp.

Cech, R., & G. Tudor. 2005. Butterflies of the East Coast: An Observer's Guide. Princeton University Press, Princeton, NJ. 345 pp.

Clark, A. H., & L. F. Clark. 1951. The butterflies of Virginia. Smithsonian Miscellaneous Collections 116: 1-239.

Opler, P. A. 1992. A Field Guide to Eastern Butterflies. Houghton Mifflin Company, Boston, MA. 396 pp.

Pavulaan, H. 1997. Checklist of Virginia butterflies (1996 revised draft edition). Privately printed, Herndon, VA. 39 pp.

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Banisteria, Number 43, pages 98-99

SOME RECORDS OF CHEWING LICE FROM CARNIVORES IN VIRGINIA. — Chewing lice are insects placed in three suborders of the Order Phthiraptera. Most species parasitize birds and thus, some refer to those as the "bird lice". However, in North America a few species are ectoparasites of rodents, ungulates, and carnivores. While surveying mammals in Virginia for fleas I also encountered a few chewing lice. Three species of trichodectid chewing lice belonging to the suborder Ischnocera from carnivores are here reported, all of which are new state records.

All of the host mammals were road kills and were brushed or combed for ectoparasites. Lice were preserved in 70% ethanol and then processed by decolorization in 5% KOH overnight, dehydrated in an ethanol series, cleared in xylene, and mounted on slides in Canada balsam. Identifications were made using the key and illustrations in Whitaker (1982). All specimens have been deposited in the collections at the Virginia Museum of Natural History, Martinsville, VA.

Stachiella octomaculatus (Paine, 1912) is a parasite of Raccoons, *Procyon lotor* as documented by Emerson (1972) and Price et al. (2003). Three of 31 (10%) Raccoons were infested from these localities: 1♂ 4♀ ex *P. lotor*, 23 September 1982, New Kent, New Kent Co., VA; 1♂ 2♀ ex *P. lotor*, 15 October 1987, Annandale, Fairfax Co., VA; 8♂ 9♀ ex *P. lotor*, 1 March 1992, Troutdale, Smyth Co., VA. Raccoons from Fairfax Co. (n=26), and one each from Arlington, Fauquier, and Prince William counties were not infested.

Stachiella larseni Emerson, 1962 is a host-specific parasite of American Mink, *Neovison vison* according to Emerson (1972) and Price et al. (2003). Only 2 American Minks were examined, one of which (50%) was infested; 1♂ 4♀ and 1 nymph ex *N. vison*, 22 February 1997, Cross Junction, Frederick Co., VA. Another mink from Dinwiddie Co. was not infested.

Neotrichodectes mephitidis (Packard, 1873) is a parasite of skunks and has been taken from the Striped Skunk, *Mephitis mephitis* and the Hooded Skunk, *Mephitis macroura* as documented by Emerson (1972) and Price et al. (2003). In this study 2 of 7 (29%) Striped Skunks were infested from these localities: 4♂ 21♀ ex *M. mephitis*, 10 November 1982, Bull Run, Prince William Co., VA; 2♀ ex *M. mephitis*, 19 September 1983, Seven Fountains, Shenandoah Co., VA. Three Striped Skunks from Fairfax Co. and one each from Fauquier and Highland counties were not infested.

Other species of chewing lice are known to parasitize other carnivore species in North America but

none were taken in this study from Gray Fox (n=8), Red Fox (n=8), Bobcat (n=2), and Coyote (n=2) in Virginia. Most species of chewing lice are very host-specific and all specimens reported here were taken from the type host species. Prevalence of infestation and parasite loads were lower than those reported by Whitaker (1982). Some of the road-kill animals were not very fresh and no detergent washing technique was used to recover lice. These differences in technique may account for the low numbers.

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LITERATURE CITED

Emerson, K. C. 1972. Checklist of the Mallophaga of North America (north of Mexico). Part III. Mammal host list. Desert Test Center, Dugway, UT. 28 pp.

Price, R. D., R. A. Hellenthal, R. L. Palma, K. P. Johnson, & D. H. Clayton. 2003. The Chewing Lice: World Checklist and Biological Overview. Illinois Natural History Survey Special Publication 24. 501 pp.

Whitaker, J. O., Jr. 1982. Ectoparasites of Mammals of Indiana. Indiana Academy of Science Monograph No. 4. Indianapolis, IN. 240pp.

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CHIRONOMID MIDGE HATCH LEADS TO MASS MORTALITY EVENT FOR CHIMNEY SWIFTS (*CHAETURA PELAGICA*). — Breeding populations of the Chimney Swift (*Chaetura pelagica*) have declined in most sectors of its breeding range in eastern North America since the initiation of standardized breeding bird surveys in 1966 (Sauer et al., 2012). Most of the decline has been attributed to range-wide reduction in the number of suitable nesting sites in chimneys and other manmade structures (Cink & Collins, 2002). However, a recent study suggested that populations at the northern periphery of its breeding range were limited by factors other than the scarcity of nesting sites (Fitzgerald et al., 2014). A third study proposed that changes in the insect prey base after the broad-scale introduction of pesticides has adversely affected swift populations (Nocera et al., 2012). Finally, mass mortality events associated with strong storms have been implicated in the recent population decline (Dionne et al., 2008). Here we report a notable mortality event caused by vehicular traffic adjacent to a midge (Chironomidae) hatch.

On 6 October 2010, at 1715 h, CJA observed several hundred swifts foraging over Interstate 295 (38° 48.77′ N, 77° 1.27′ W) and the adjacent Blue Plains Advanced Wastewater Treatment Plant in Washington, District of Columbia. An estimated 300 swifts were dead on the north- and southbound lanes of the highway and mowed right-of-way (Fig. 1). CJA salvaged sixty of the more intact carcasses for preservation as museum specimens. On the morning of 7 October, we revisited the site and observed several hundred swifts foraging low over the wastewater treatment plant and highway. We salvaged an additional 30 carcasses from the highway right-of-way. A return trip on 8 October revealed only a few swifts foraging over the wastewater treatment plant. The closest treatment ponds were only 30 m from the mowed highway right of way. The District of Columbia Water and Sewer Authority (DCWSA) was contacted to determine if there was a direct connection between the swift mortality event and the sewage treatment plant. Representatives from the DCWSA, the District of Columbia Department of Health, Fire and Emergency Medical Services, and the National Guard Civil Support Team determined that there were no chemicals or hazardous materials at the wastewater treatment plant that could have caused the

Fig. 1. Chimney Swifts (*Chaetura pelagica*) killed by automotive traffic adjacent to the Blue Plains Advanced Wastewater Treatment Plant in the District of Columbia on 6 October 2010.

deaths and that the birds had most likely been struck by cars. During specimen preparation, we confirmed signs of blunt-force trauma, including broken sterna and pneumatized skulls filled with blood, further confirming the collision hypothesis.

Smithsonian and US Geological Survey staff prepared 79 individuals as museum skins and partial skeletal specimens. The stomachs, all packed with insects, were preserved in ethanol. Specimens consisted of 45 males, 24 females, and 10 that could not be sexed. The majority were hatch year individuals (n = 43). Twenty-three were adults (after hatching year) and the age of the remaining individuals (n = 13) could not be determined. JHE identified the stomach contents of two individuals (USNM 644439 and USNM 644447). One species of chironomid midge (*Chironomus calligraphus*) constituted 99.5% of the 1365 insects in the two stomachs. Bulk samples of stomach contents and swift specimens were deposited in the Division of Birds, National Museum of Natural History, Smithsonian Institution.

Chironomidae (non-biting midges), especially members of the genus *Chironomus*, are often dominant members of insect faunas of sewage treatment plants. Eutrophic conditions prevalent at these facilities can promote the growth of huge populations of emerging midges that may create severe nuisance situations for animals and humans. *Chironomus calligraphus*, a Neotropical species, was first reported in the United States from California (Spies, 2000). It was present in Florida at least as early as 1965 (Spies et al., 2002) but because of difficulties associated with species level identification of *Chironomus*, it remained essentially unnoticed. The northernmost record in the eastern United States was recently reported from southern Georgia (Gray et al., 2012). The collection of this species from the District of Columbia represents a significant northward range extension. The species may have been present for years, but, as noted above, difficulties associated with species level identification of many *Chironomus* species (see Spies et al., 2002) have allowed this species to remain taxonomically undetected. Laboratory and field investigations in Argentina have shown that *C. calligraphus* has a temperature-dependent life cycle with a minimum generation time of 18 days, with several overlapping cohorts in spring through summer and one to two generations in winter (Zilli et al., 2008).

The Blue Plains mortality event was one of the largest on record for swifts (Cink & Collins, 2002; Dionne, et al., 2008) and certainly the largest caused by automobile collision at a single site (Glista et al., 2008). The frequency of such events is unknown but if large chironomid midge hatches occur annually at the Blue Plains site during the first two weeks of October, then significant swift mortality may be a regular occurrence.

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LITERATURE CITED

Cink, C. L., & C. T. Collins. 2002. Chimney Swift (*Chaetura pelagica*). The Birds of North America Online (A. Poole, ed.). Cornell Lab of Ornithology, Ithaca, NY. http://bna.birds.cornell.edu/bna/species/646

Dionne, M., C. Maurice, J. Gauthier, & F. Shaffer. 2008. Impact of Hurricane Wilma on migrating birds: the case of the Chimney Swift. Wilson Journal of Ornithology 120: 784-792.

Fitzgerald, T. M., E. van Stam, J. J. Nocera, & D. S. Badzinski. 2014. Loss of nesting sites is not a primary factor limiting northern Chimney Swift populations. Population Ecology 56: in press DOI: 10.1007/s10144-014-0433-6

Glista, D. J., T. L. DeVault, & J. A. DeWoody. 2008. Vertebrate road mortality predominately impacts amphibians. Herpetological Conservation and Biology 3: 77-87.

Gray, E. W., C. Royals, J. H. Epler, R. D. Wyatt, B. Brewer, & R. Noblet. 2012. *Chironomus calligraphus* (Diptera: Chironomidae), a new pest species in Georgia. Journal of the American Mosquito Control Association 28: 258-259.

Nocera, J. J., J. M. Blais, D. V. Beresford, L. K. Finity, C. Grooms, L. E. Kimpe, K. Kyser, N. Michelutti, M. W. Reudink, & J. P. Smol. 2012. Historical pesticide applications coincided with an altered diet of aerially foraging insectivorous chimney swifts. Proceedings of the Royal Society B 279: 3114-3120.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, & W. A. Link. 2012. The North American Breeding Bird Survey, Results and Analysis 1966 - 2011. Version 07.03.2013 USGS Patuxent Wildlife Research Center, Laurel, MD.

Spies, M. 2000. Non-biting "nuisance" midges (Diptera, Chironomidae) in urban southern California, with notes

on taxonomy, ecology and zoogeography. Pp. 621-628 *In* O. Hoffrichter (ed.), Late 20th Century Research on Chironomidae: An Anthology from the 13th International Symposium on Chironomidae. Shaker Verlag, Aachen.

Spies, M., J. E. Sublette, M. F. Sublette, W. F. Wülker, J. Martin, A. Hille, M. A. Miller, & K. Witt. 2002. Pan-American *Chironomus calligraphus* Goeldi, 1905 (Diptera: Chironomidae): species or complex? Evidence from external morphology, karyology and DNA sequencing. Aquatic Insects 24: 91-113.

Zilli, F. L., L. Montalto, A. C. Paggi, & M. R. Marchese. 2008. Biometry and life cycle of *Chironomus calligraphus* Goeldi 1905 (Diptera, Chironomidae) in laboratory conditions. Interciencia 33: 767-770.

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Banisteria, Number 43, pages 101-103

SNAKE PREDATION ON AMERICAN OYSTERCATCHER EGGS ON FISHERMAN ISLAND, VIRGINIA. — Fisherman Island National Wildlife Refuge is located at the tip of the Delmarva Peninsula in the mouth of the Chesapeake Bay. The island is an important breeding area for several species of beach-nesting birds, including American Oystercatchers (*Haematopus palliatus*), Least Terns (*Sternula antillarum*), and Piping Plovers (*Charadrius melodus*) (Wilke et al., 2007; Denmon et al., 2013). A bridge connecting the mainland to the island, as well as their close proximity (ca. 600 m), has facilitated the presence of mammalian and avian predators, including Raccoons (*Procyon lotor*), American Crows (*Corvus brachyrhynchos*), Fish Crows (*Corvus ossifragus*), Herring Gulls (*Larus argentatus*), and Laughing Gulls (*Leucophaeus atricilla*), all of which prey on birds, eggs, and nestlings (Nol, 1989; Sabine et al., 2006). Here we summarize observations of a large snake that consumed eggs from an American Oystercatcher nest. Two species of snakes known to eat bird eggs, Eastern Ratsnake (*Pantherophis alleghaniensis*) and North American Racer (*Coluber constrictor*), have been documented for Fisherman Island (Mitchell & Reay, 1999; Mitchell, 2012) and both are potential predators of birds that nest on this barrier island (Fitch, 1963; Mitchell, 1994).

During the 2006 American Oystercatcher breeding season, U.S. Fish and Wildlife Service staff deployed several wildlife cameras on Fisherman Island to monitor nest success using the techniques described in Denmon et al. (2013). Each camera was mounted to a post that was buried with about 0.5 m visible above ground. Posts were camouflaged using wrack from the beach and all wires were spray-painted light tan and covered with sand. The cameras took pictures every five seconds; because the data consisted of a series of digital pictures rather than video footage, images were often grainy and only of fair quality.

The nest identified as 6F51 was located on the northwest side of Fisherman Island. The habitat consisted of low sand dunes with piles of wrack and some beach grasses. Directly behind the nest (shoreward) was a sheer sand cliff topped with grasses that resulted from erosion. Thick grassland and shrubs constitute the upland habitat in the area. The oystercatcher pair at this site laid their first egg on 18 May 2006; a second egg was laid by 20 May. Camera deployment was delayed until 25 May to reduce the chance of the birds abandoning the nest.

Analysis of the digital images taken at nest 6F51 on

the night of 9 June 2006 revealed that at 1846 h EDT the incubating oystercatcher left the nest and began looking to the north. It then proceeded to pace up and down a dune south of the nest. A snake first appeared on camera at 1849 h, moving in from the northeast and arrived at the nest at 1854 h. At this time, the oystercatcher headed back to the nest and began moving in a random pattern, circling the nest, then retreating and running along the southern dune, then returning and circling again. At 1907 h, the bird appeared to be staying very close to the nest and had increased its circling and pacing. The snake cannot be seen at this point due to vegetation obstructing the view, but it appeared that the bird was attempting to scare the predator away. After a few minutes, the oystercatcher ceased its circling behavior, moved to the left of the camera, and continued pacing the dune.

The oystercatcher made a final attempt at 1914 h to defend the nest; the snake is again visible in this frame. The bird resumed its pacing at the southern dune and seemed to be in a state of distress. The snake moved away at 1934 h and is out of the camera frame a minute later. The oystercatcher returned to the nest and then left the area at 1944 h. The snake (presumably the same one) returned later that evening (from the south) and proceeded to the nest at 2124 h, where it remained until 2132 h, when it moved away to the south again. The nest site was completely empty upon examination the next day; there were no eggshell fragments or tracks. We assume the snake swallowed both eggs. This behavior is similar to that seen in an insular milksnake (*Lampropeltis triangulum*) on Isla Isabel in Mexico, where specific nests were visited by the same snake up to three times in a single night over a two-hour period (Rodriguez & Drummond, 2000).

Due to the poor quality of the images, we were unable to precisely identify the snake to species. However, based on its size, movement, and coloration, we postulated that it was either an Eastern Ratsnake or North American Racer. On 26 June 2006, one of us (J. Mitchell) set 60 minnow traps in the vicinity of the nest under vegetation and caught a large (1,370 mm total length) female racer on 28 June. We concluded from this information that the snake that ate the American Oystercatcher eggs was most likely this or another large North American Racer.

American Oystercatcher productivity on Fisherman Island in 2006 was very poor, with 42 pairs successfully fledging only 13 chicks (P. Denmon, unpubl. data). Egg predators of this species known to occur on the island include Raccoons, American Crows, and several species of gulls. To this list we add the North American Racer. This snake species is attracted to habitat edges where American Oystercatchers often nest because they are thermally optimal habitats and where greater prey abundance often occurs (Weatherhead & Blouin-Demers, 2004). Because they locate prey visually, these snakes may be more attracted to nests where the parents are active. We hypothesize that North American Racers are attracted to potential prey (e.g., bird eggs) by watching adult movements. Wildlife cameras coupled with the use of radio-transmitters in the snakes might allow such behaviors to be watched and recorded in nature. Experimental tests with racers in outdoor enclosures with simulated moving adults and stationary eggs may also elucidate this form of predatory behavior.

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LITERATURE CITED

Denmon, P., B. D. Watts, & F. M. Smith. 2013. Investigating American Oystercatcher (*Haematopus palliatus*) nest failure on Fisherman Island National Wildlife Refuge, Virginia, USA. Waterbirds 36: 156-165.

Fitch, H. S. 1963. Natural history of the racer, *Coluber constrictor*. University of Kansas Publications, Museum of Natural History 15: 351-468.

Mitchell, J. C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, DC. 352 pp.

Mitchell, J. C. 2012. Amphibians and reptiles of the Eastern Shore of Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge. Banisteria 39: 21-33.

Mitchell, J. C., & K. K. Reay. 1999. Atlas of Amphibians and Reptiles in Virginia. Special Publication No. 1, Virginia Department of Game and Inland Fisheries, Richmond, VA. 122 pp.

Nol, E. 1989. Food supply and reproductive performance of the American Oystercatcher in Virginia. Condor 91: 429-435.

Rodriguez, M. C., & H. Drummond. 2000. Exploitation of avian nestlings and lizards by insular milksnakes, *Lampropeltis triangulum*. Journal of Herpetology 34:

139-142.

Sabine, J. B., S. H. Schweitzer, & J. M. Meyers. 2006. Nest fate and productivity of American Oystercatchers, Cumberland Island National Seashore, Georgia. Waterbirds 29: 308-314.

Wilke, A. L., D. F. Brinker, B. D. Watts, A. H. Traut, R. Boettcher, J. M. McCann, B. R. Truitt, & P. P. Denmon. 2007. American Oystercatchers in Maryland and Virginia, USA: status and distribution. Waterbirds 30(sp1): 152-162.

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Miscellanea

Reports

1. President's Report

We are still searching for a nominee to fill a vacant Councilor position and this fall we will need nominees for Vice-President and another Councilor position. If you are interested in nominating someone or running for one of these positions, please contact me at tfredericksen@ferrum.edu.

The next issue of *Banisteria* will contain a special section on moths in Virginia. Please consider our journal as an outlet for research papers and field notes. Volumes are published in the spring and fall.

Our first Virginia Natural History Society newsletter was published in March. The newsletter will be published biannually in the intervening quarters between the issues of *Banisteria.* The newsletter will be circulated among the VNHS membership and posted on the Virginia Master Naturalist Program list serve. We hope to obtain contributions from our members as well as from Master Naturalist members. Please submit contributions to Richard Groover at rgroover@reynolds.edu.

Respectfully submitted
Todd Fredericksen, President
Virginia Natural History Society

2. Minutes of the Council of the Virginia Natural History Society Meeting of December 7, 2013

The 2013 meeting of the Executive Committee of the Virginia Natural History Society was called to order by President Todd Fredericksen at 1:15 PM on December 7, 2013, in Settle Hall at Hampden-Sydney College, Hampden-Sydney, Virginia. In attendance were Ralph Eckerlin, Bill Shear, Steve Roble, Todd Fredericksen, Barry Knisley, Richard Groover, Michael Lachance, and Nancy Moncrief.

The minutes of the 2012 meeting and the report of the Secretary-Treasurer were approved unanimously. A current report is appended to these minutes.

Steve Roble presented the Editor's report. *Banisteria* No. 40, for autumn 2012, was a memorial issue dedicated to Richard Hoffman and contained articles by him, some dating back to his teenage days as a nature columnist for the Clifton Forge newspaper. Number 41 contained seven papers derived from the 2009 History of Natural History symposium, plus several additional papers and shorter contributions. Number 42, now being printed, focuses on the biospeleology of Virginia. Sufficient articles are lined up for No. 43, and it is possible that No. 44 will be a special issue on moths. Editor Roble briefly mentioned the possibility of going entirely to electronic publication for *Banisteria,* and reminded the council that there was at present no successor in line should he retire or otherwise be unable to continue as editor. The scanning of past *Banisteria* issues for posting online appears to be stalled, but Editor Roble will contact Tom McAvoy to determine if this process can be revived. It is anticipated that the biospeleology issue may generate requests for copies from nonmembers, and the council decided to keep the price of $20 for single issues, but if 10 or more issues were ordered, the price would be reduced to $10 per copy, plus shipping.

It was also noted that webmaster John White has now placed the society's website on a private server, for which we pay a small annual fee.

Todd Fredericksen presented the President's report. As at previous meetings, the report and the subsequent discussion focused on ways to increase membership. Bill Shear and Todd Fredericksen remarked that the discussion had become perennial, and while many ideas were presented, no action is ever taken. Shear urged that an annual meeting be instituted, and Nancy Moncrief said that the Virginia Museum of Natural History would probably be able to host such a meeting as they have done in the past. Tentatively, a meeting could be planned for 2015, 2014 being regarded as "too soon." President Fredericksen said he would commence outreach to the Master Naturalists of Virginia and other groups to prepare for a projected 2015 meeting.

Ralph Eckerlin said he was continuing to work on the revision of the bylaws and he tries to increase membership by sending a personal letter and application form to scientists from Virginia and adjacent states who have published natural history type research in the journals *Northeastern Naturalist* and *Southeastern Naturalist*. The Virginia Academy of Science (VAS) has again invited VNHS members to present at its 2014 meeting without the need to be a VAS member. Council members agreed this would be good, so Eckerlin will send a call for titles to Secretary Shear to be disseminated electronically.

The meeting adjourned at 3:16 PM.

Respectfully submitted,
William A. Shear, Secretary/Treasurer
Virginia Natural History Society

Secretary-Treasurer's Report, December 2013

As of December 12, 2013, the society has 109 members, including 17 institutions. This is the same membership as December 2012. Our current bank balance is $9237.71, up from $8353.00 from six months ago.

3. Secretary-Treasurer's Report, April 2014

As of April 24, 2014, the society has 78 members, including 8 institutions. This represents a decrease in membership from December 2013 (109 members, 17 institutions). In December 2012, we had the same number of members and the same number of institutions. Except for 2011, membership has declined or remained the same over the past ten years from the most recent high point in 2004, when we enrolled 165 members, including 22 institutions.

Our current bank balance is $9968.42, up from $9237.71 from six months ago.

Up to April 24, 2014, 51 copies of Banisteria #42 (Virginia Cave Fauna) above those distributed to the membership have been sold.

Respectfully submitted,
William A. Shear, Secretary/Treasurer
Virginia Natural History Society

4. Webmaster's Report

VNHS website traffic from December 1, 2013 to June 14, 2014 is summarized in the table below. Unfortunately, web traffic data were not captured for March and April 2014.

Month	Sites	Visits	Pages	Files	Hits
December	1552	609	1157	3233	7091
January	1501	664	1685	3329	9229
February	340	111	218	661	1540
May	1003	683	1288	2337	5597
June	605	507	849	1334	3081
Total	-----	2574	5197	10984	26538

The following are the top five, most frequently viewed pages for June 2014:

1. Banisteria No. 33 - *Phyllophaga spreta* (Horn), A Rare Species of June Beetle New to the Fauna of Virginia, North Carolina, and Pennsylvania (Coleoptera: Scarabaeidae) – Arthur V. Evans

2. Banisteria - Main Page

3. Banisteria No. 23 - Arthropod Community Heterogeneity in a Mid-Atlantic Forest Highly Invaded by Alien Organisms - Daniel Kjar and Edward M. Barrows

4. Banisteria No. 2 - Moth Records from Burkes Garden, Virginia - Kenneth J. Stein

5. Banisteria No. 24 - Status of the Appalachian Grizzled Skipper (*Pyrgus centaureae wyandot*) in Virginia - Anne C. Chazal, Steven M. Roble, Christopher S. Hobson, and Katharine L. Derge

The VNHS website has been redesigned and is now mobile device compliant. Additional features and functionality will be added as time allows.

Respectfully submitted,
John White, Webmaster
Virginia Natural History Society

5. Editor's Report

Earlier this year I prepared about 100 new or revised pdf versions of past *Banisteria* articles from numbers 14-38 for posting on the Virginia Natural History Society's website. When available, I replaced black and white photographs with color images. All of these files, plus additional articles from older issues that were scanned by or under the supervision of past president Tom McAvoy, are now available as free downloads. We will continue to work toward the goal of having all articles from issues of *Banisteria* more than 2 years old available on the society's website. Titles and selected abstracts of recent issues will continue to be posted on the website.

This issue of *Banisteria* features a wide variety of papers on the biota of Virginia, ranging from snails, root fungi, and dragonflies to fish, turtles, and birds. I thank Tom Wieboldt for serving as editor of the note concerning the discovery of Harris' Checkerspot in Virginia.

I plan to devote the next issue of the journal to a series of papers on the diverse moth fauna of the state. Manuscripts received in the latter half of 2014 will largely comprise the first issue of 2015. Currently, there is no backlog of manuscripts, so consider submitting your unpublished research projects, surveys, and natural history observations to help us maintain a biannual publication schedule.

Respectfully submitted,
Steve Roble, Editor, *Banisteria*

Virginia Natural History Society

http://virginianaturalhistorysociety.com/

General Information

The Virginia Natural History Society (VNHS) was formed in 1992 to bring together persons interested in the natural history of the Commonwealth of Virginia. The VNHS defines natural history in a broad sense, from the study of plants, animals, and other organisms to the geology and ecology of the state, to the natural history of the native people who inhabit it. The goals of the VNHS are to promote research on the natural history of Virginia, educate the citizens of the Commonwealth on natural history topics, and to encourage the conservation of natural resources.

Dissemination of natural history information occurs through publication of the journal *Banisteria*, named for John Banister (1650-1692) who was the first university-trained naturalist to work in Virginia. The first issue was published in 1992, and the journal is published twice per year in spring and fall. Articles cover a wide array of subjects, and prospective authors are encouraged to submit manuscripts on any aspect of natural history in Virginia; papers may pertain to Virginia or regional archaeology, anthropology, botany, ecology, zoology, paleontology, geology, geography, or climatology. Book reviews, biographies, obituaries, and historical accounts of relevance to natural history in Virginia also are welcomed. Manuscripts are peer-reviewed for suitability and edited for inclusion in the journal.

Page charges ($20/page) are waived if the sole or first author is a VNHS member. All authors must pay $75/page if they desire color printing of figures. The society's website contains detailed instructions for authors and the titles, abstracts or full PDF versions of articles from past *Banisteria* issues.

Memberships

The VNHS is open to anyone with an interest in natural history and welcomes participation by all members in society activities and efforts to promote education and conservation. Membership includes a subscription to *Banisteria* and invitations to periodic symposia and field events. Annual dues for members are $20 (per calendar year); library subscriptions are $40 per year. Checks or money orders (credit cards are not accepted) should be sent to the Secretary/Treasurer, who also has back issues of *Banisteria* available for sale. The VNHS is a tax-exempt, nonprofit, society under Section 501(C)3 of the IRS. We welcome donations to support our mission in Virginia.

Virginia Natural History Society

Application for Membership

Name _____

Address_____

_____

_____

Zip Code _____

Phone _____

Email _____

Area(s) of Interest _____

ANNUAL DUES AND SUBSCRIPTIONS TO *BANISTERIA*

(memberships and subscriptions are by calendar year; subscribers/members outside the United States should add $3.00 for additional postage)

- ☐ $500.00 Life (not annual)
- ☐ $300.00 Benefactor
- ☐ $100.00 Patron
- ☐ $50.00 Supporting
- ☐ $40.00 Institutional
- ☐ $25.00 Family
- ☐ $20.00 Regular
- ☐ $5.00 Student (see below)

☐ I have added a contribution of $_____ to my membership dues.

The special student rate is applicable only when accompanied by the following certification signed by a faculty advisor.

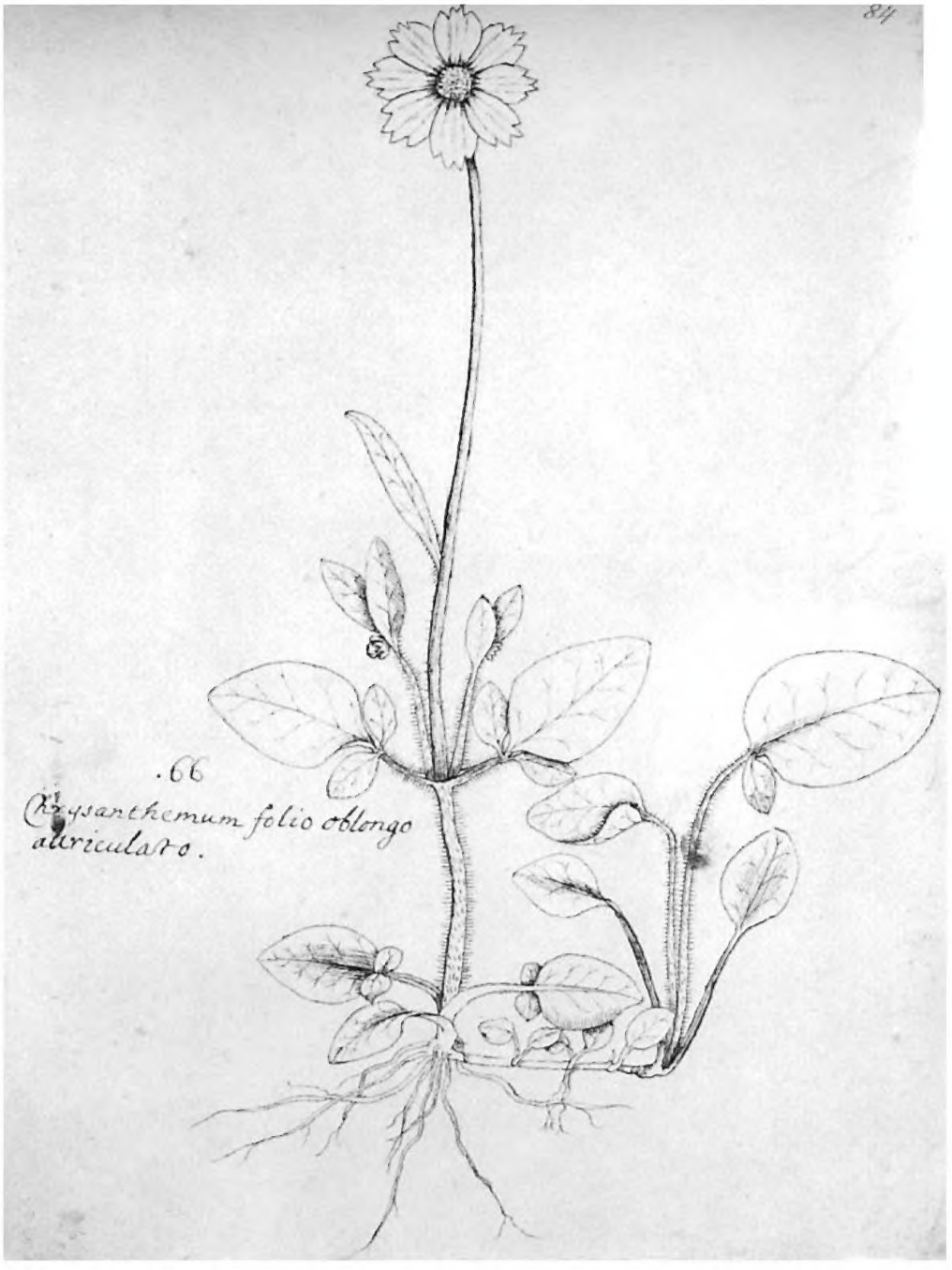
Institution _____

Advisor _____

Date_____

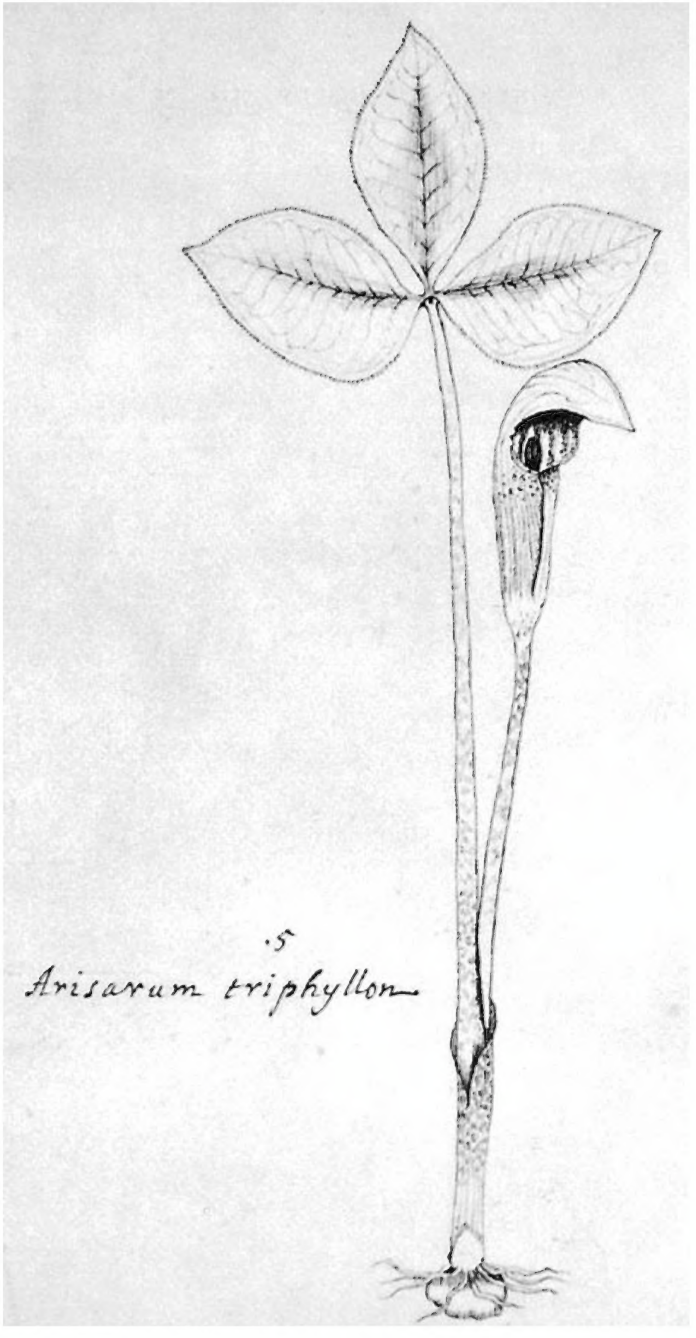
Make checks or money orders payable to:
Virginia Natural History Society

Send membership form and dues to:
Dr. William Shear, Secretary-Treasurer
Virginia Natural History Society
Box 96
Hampden-Sydney, VA 23943



Coreopsis auriculata Linnaeus

Original drawing by John Banister. Figure 84 in folio in Hans Sloane's MS 4002 in the British Museum of Natural History. Photograph courtesy of Joseph and Nesta Ewan.



5
Arisarum triphyllon